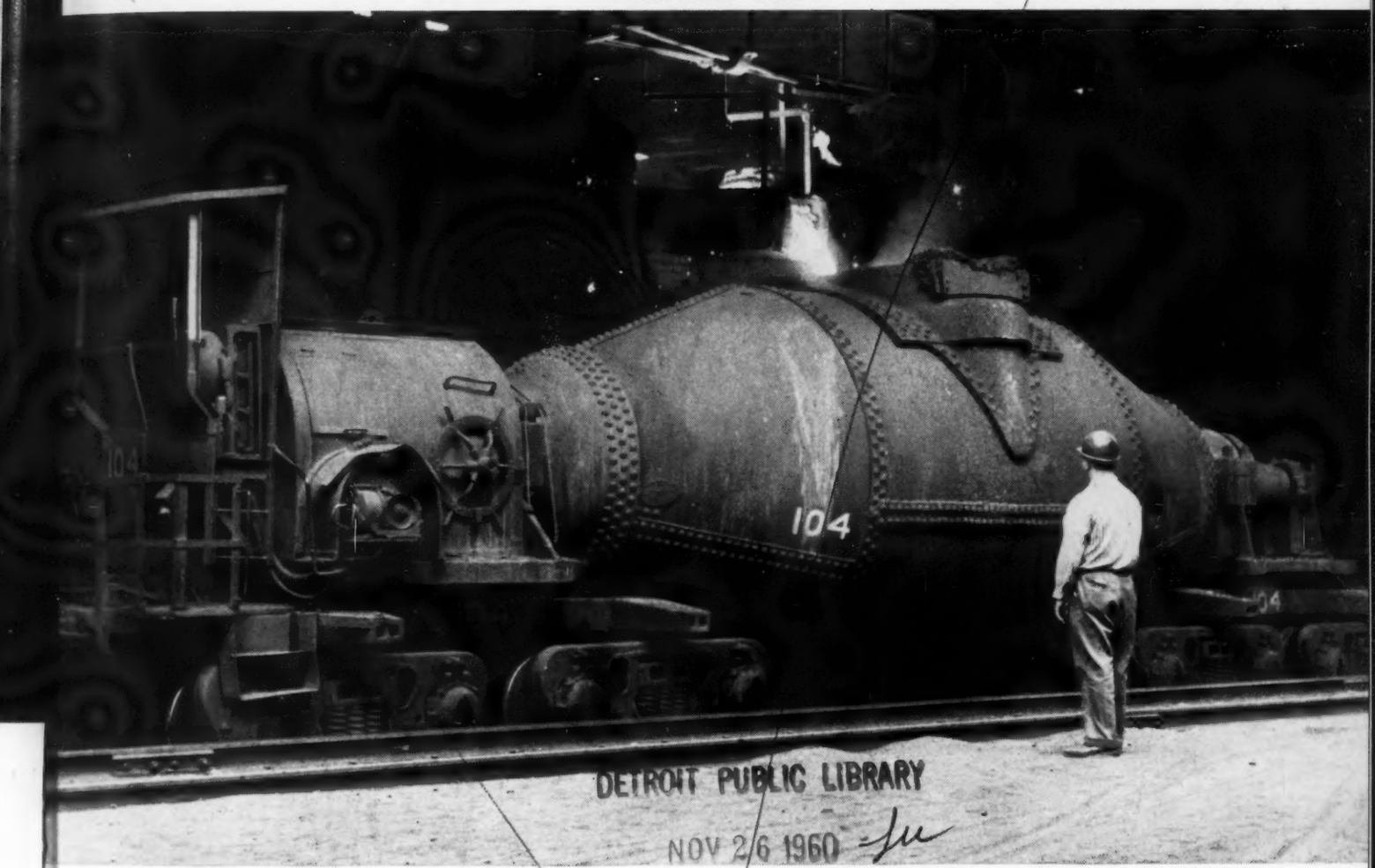
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

NOVEMBER 1960



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TECHNOLOGY

How mixer-type hot metal cars roll cool at J & L Aliquippa

Transporting *all* the iron produced at Jones & Laughlin's Aliquippa Works is the big job done by fourteen mixer-type hot metal cars like the one shown above. To make sure wheel bearings run cool and keep running even under heaviest loads and impacts, car builder M. H. Treadwell Co. Inc., specified Timken® tapered roller bearings for all the car journals.

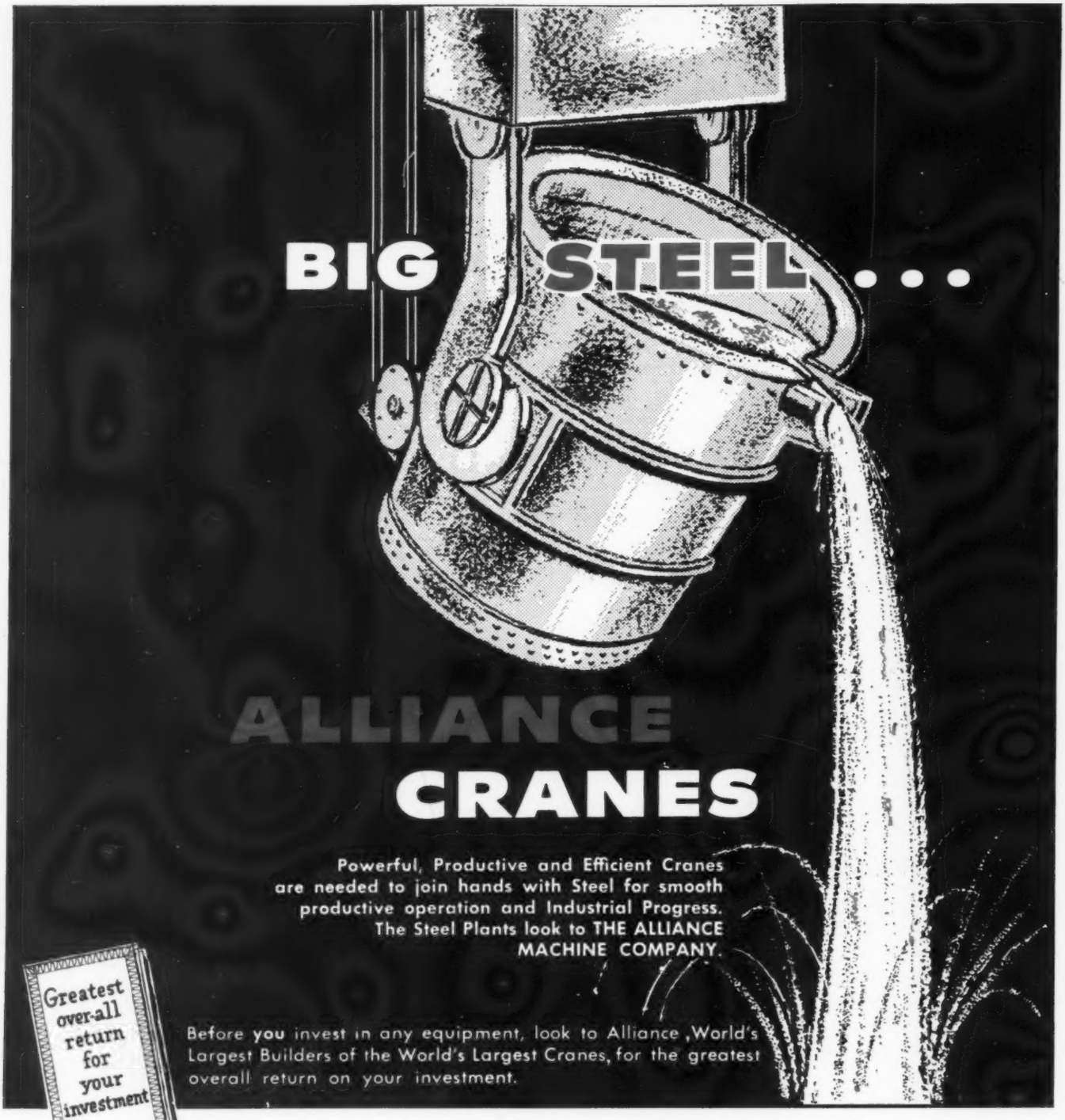
Because they roll the load, Timken bearings practically eliminate friction. Cars start and roll easier, save power. Because of their taper, Timken bearings take any combination of radial and thrust loads. And full-line contact between rollers and races gives Timken bearings extra load-carrying capacity. Bearings run longer, smoother. Axles run true, minimizing on-the-spot wheel and rail wear. Maintenance is reduced to a minimum.

Call on our graduate engineer salesmen for expert engineering service on your bearing applications. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ontario.

Industry rolls on

TIMKEN®

tapered roller bearings


BIG STEEL . . .
ALLIANCE
CRANES
Powerful, Productive and Efficient Cranes are needed to join hands with Steel for smooth productive operation and Industrial Progress. The Steel Plants look to THE ALLIANCE MACHINE COMPANY.
Greatest over-all return for your investment
A
Before you invest in any equipment, look to Alliance, World's Largest Builders of the World's Largest Cranes, for the greatest overall return on your investment.

"Give Us The Runway and We'll Lift The World"

Overhead Cranes * Gantry Cranes * Mill Cranes and Equipment * Hot Metal Cranes * Ladle Cranes Stripper Cranes * Soaking Pit Cranes * Soaking Pit Cover Cranes * Charging Machines * Furnace Chargers * Slab Handling Cranes * Bucket Cranes Magnet Cranes * Mold Yard Cranes * Skull Cracker Cranes * Ingot Buggies * Run-Out Tables Car Dumpers * Special Mill Equipment * Ore & Coal Bridges * Loading & Unloading Towers Forging Manipulators * Forging Cranes * Power House & Dam Cranes * Dock & Pier Handling Equipment * Research, Development & Engineering Service * Licensees & Manufacturing Facilities in Other Countries

the Alliance

machine company

Main Office • Alliance, Ohio

Automatic Bull Block

for copper

Place coil in tray and feed point into die. Press the button, that's all. This Automatic Bull Block does the rest. Finished tubing emerges. Features include Automatic Gripping, Automatic Grip Release, Heavy Traverse Feed.

This is a 36" Bull Block drawing down copper from 5/8" to 1/8" at high speeds.

The Automatic Bull Block can be furnished in all sizes up to 84" diameter. Producing long lengths at high speeds automatically really brings down those costs. For complete information on the Block or any other Cold Draw equipment for tubes, bars, or shapes, write to: Cold Draw, Aetna-Standard Division, Blaw-Knox Company, Pittsburgh 30, Pennsylvania.

Aetna-Standard Division
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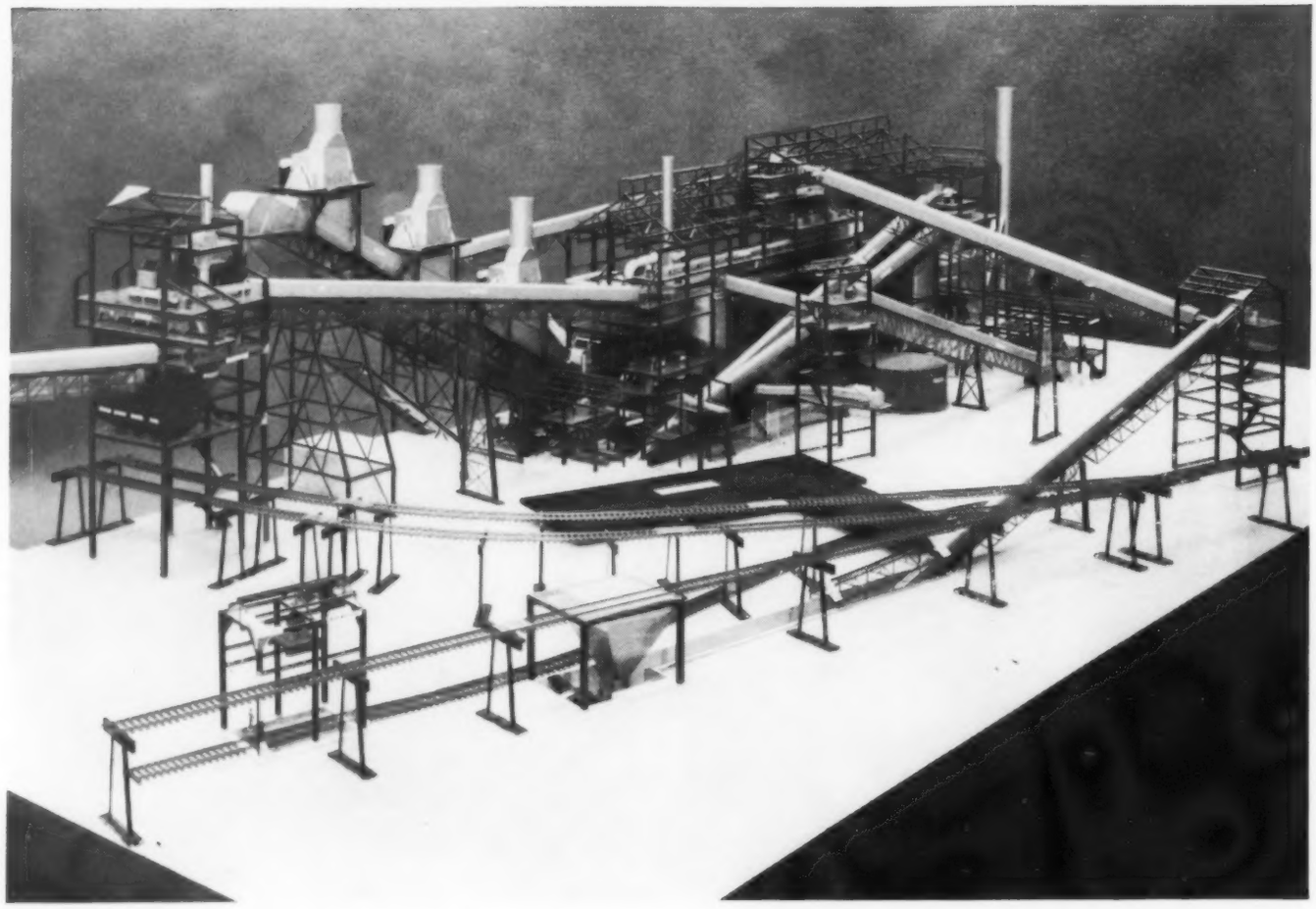

Scale model of the newest Dravo-Lurgi sintering plant, now under construction for Interlake Iron Corporation.

47,500 tons per day

Dravo-Lurgi Sintering and Pelletizing Plants, some still under construction, will produce in excess of 15,500,000 tons of sinter or pellets per year.

Listed here are the major Dravo-Lurgi projects:

In Operation	For	No. Machines	Capacity
Gary	United States Steel Corp.	3	15,000 tpd
Saxonburg	United States Steel Corp.	3	15,000 tpd
Ashland	Armco Steel Corp.	1	2,400 tpd
Trenton #1	McLouth Steel Co.	1	2,100 tpd
Trenton #2	McLouth Steel Co.	1	2,100 tpd
Copper Cliff, Ont.	International Nickel Co.	1	1,100 tpd
Under Construction			
Chicago	Interlake Iron Corporation	1	3,300 tpd
Aliquippa	Jones & Laughlin Steel Corporation	1	6,500 tpd
		Total:	47,500 tpd

In addition to these complete plants, Dravo has built sinter coolers of several types for a number of existing sinter machines. These coolers are designed to reduce sinter temperatures at the maximum rate consistent with minimum shattering, and unload the cooled sinter without further breaking.

This extensive experience with sintering and pelletizing plant design and construction can be brought to bear on your specific requirements. We will be glad to discuss the latest techniques in ore agglomeration with you or your staff. Write or phone Dravo Corporation, Pittsburgh 22, Pa.

DRAVO
CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • docks and unloaders • dredging • fabricated piping foundations • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

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Iron AND Steel ENGINEER

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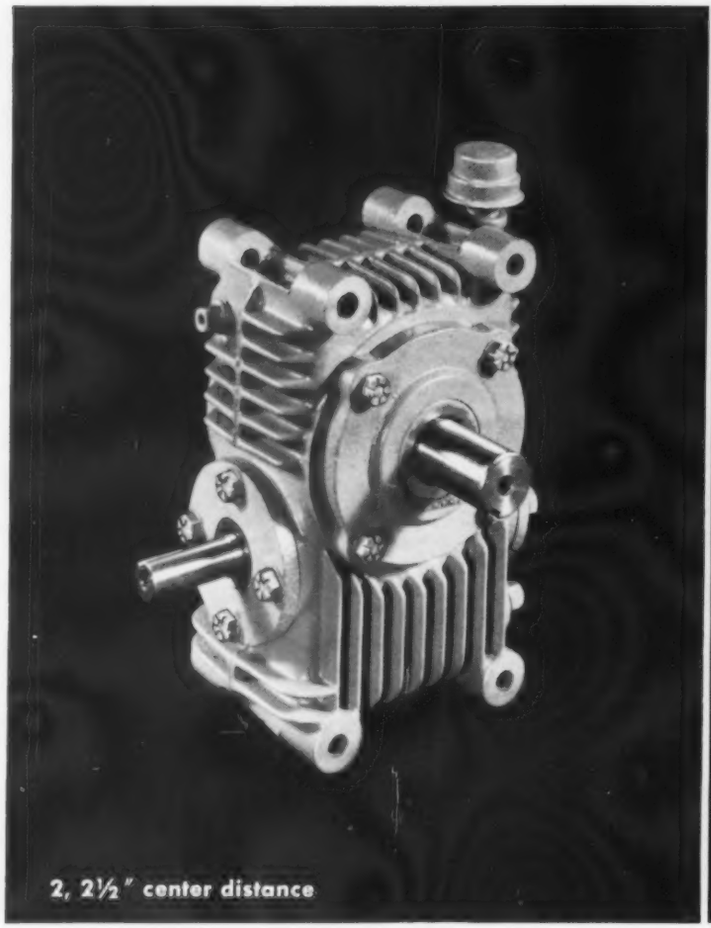

2, 2½" center distance

3, 3½" center distance

Custom-build Your Worm Gear Drive from . . .

OVER 200,000 STOCK

The four "worm-under" speed reducers shown above represent only eleven sizes of standard, Cone-Drive units. Also standard are 15", 18", 22", and 24" center distance units. Cone-Drive worm gear reducers are available in ratios from 5:1 to 4900:1 and up to over 1200 HP capacity. All units feature the double-enveloping principle in which the worm and gear wrap around each other for greatest tooth contact, strength, smoothness, shock-resistance and quietness of operation.

All Cone-Drive worm-gear reducers feature heavy, ribbed, nickel-iron castings for maximum strength and heat dissipation. Heavy-duty taper roller bearings provide anti-friction support to both worm and gear shafts. Chrome-molybdenum-nickel steel worms and tin bronze gears provide long life and high strength. The Cone-Drive design also gives the exclusive benefit that, in service, both gear and worm tend to regenerate their true form . . . worm and gear wear "in" rather than "out."

Standard Options

By selecting various options, standard units can be obtained to fit almost any drive requirements. By taking advantage of these options in the early design stages, you can often simplify design and improve performance, too. Including size and ratio ranges and options available, Cone-Drive Gears offers over 200,000 worm-gear speed reducer combinations that are standard, shelf-hardware items. Special sizes and ratios can be furnished on a quotation basis. Write for Bulletin CD-218 for complete details.

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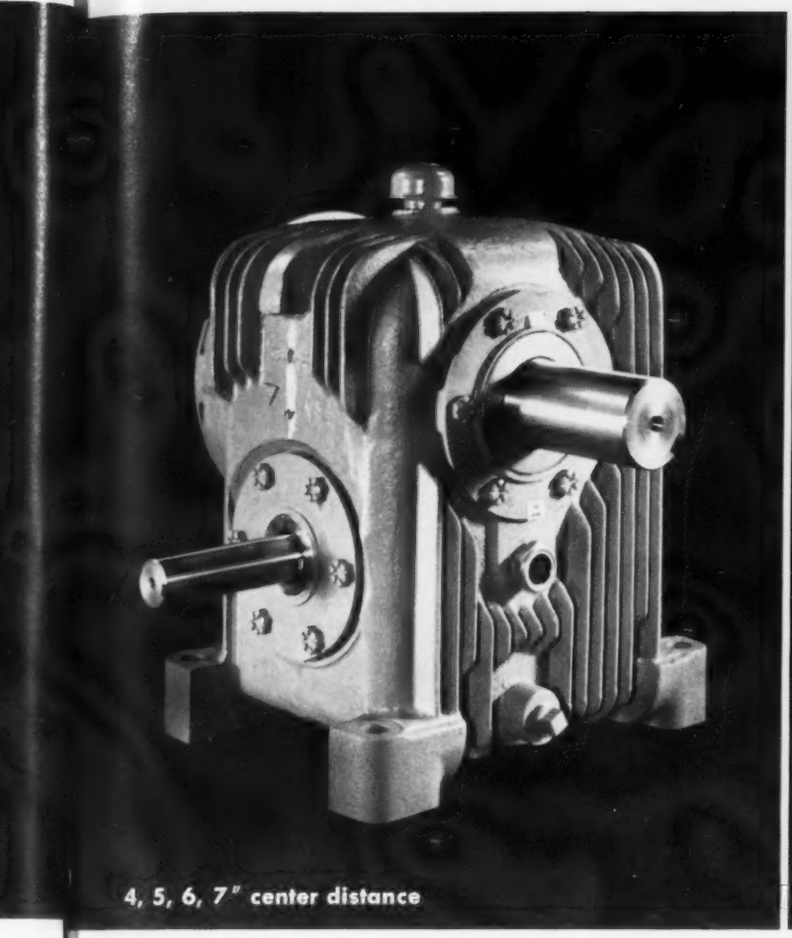
DOUBLE-ENVELOPING WORM GEARSETS

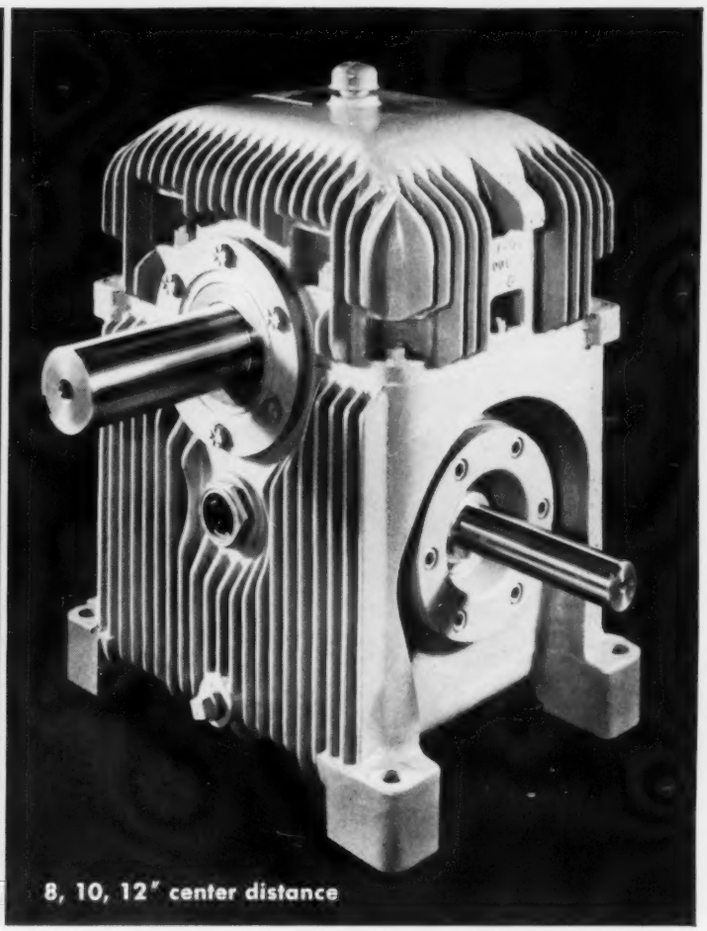
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS



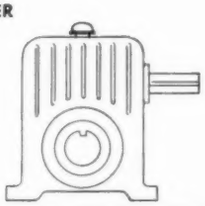
4, 5, 6, 7″ center distance



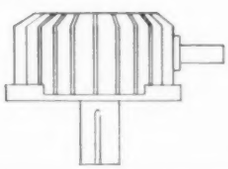
8, 10, 12″ center distance

CONE-DRIVE REDUCERS

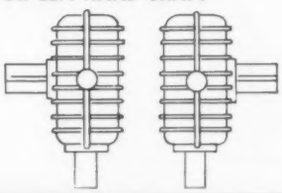
WORM-OVER



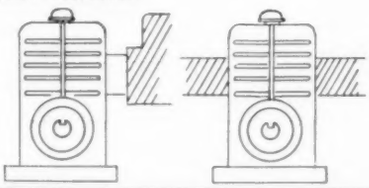
VERTICAL GEARSHAFT



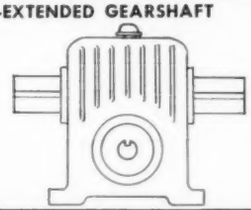
RIGHT- OR LEFT-HAND SHAFT



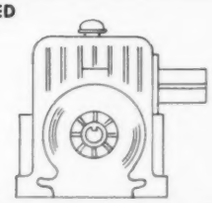
SHAFT MOUNTED



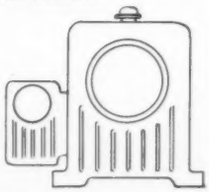
DOUBLE-EXTENDED GEARSHAFT



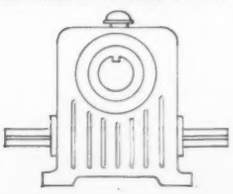
FAN-COOLED



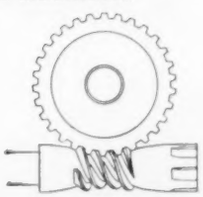
DOUBLE REDUCTION

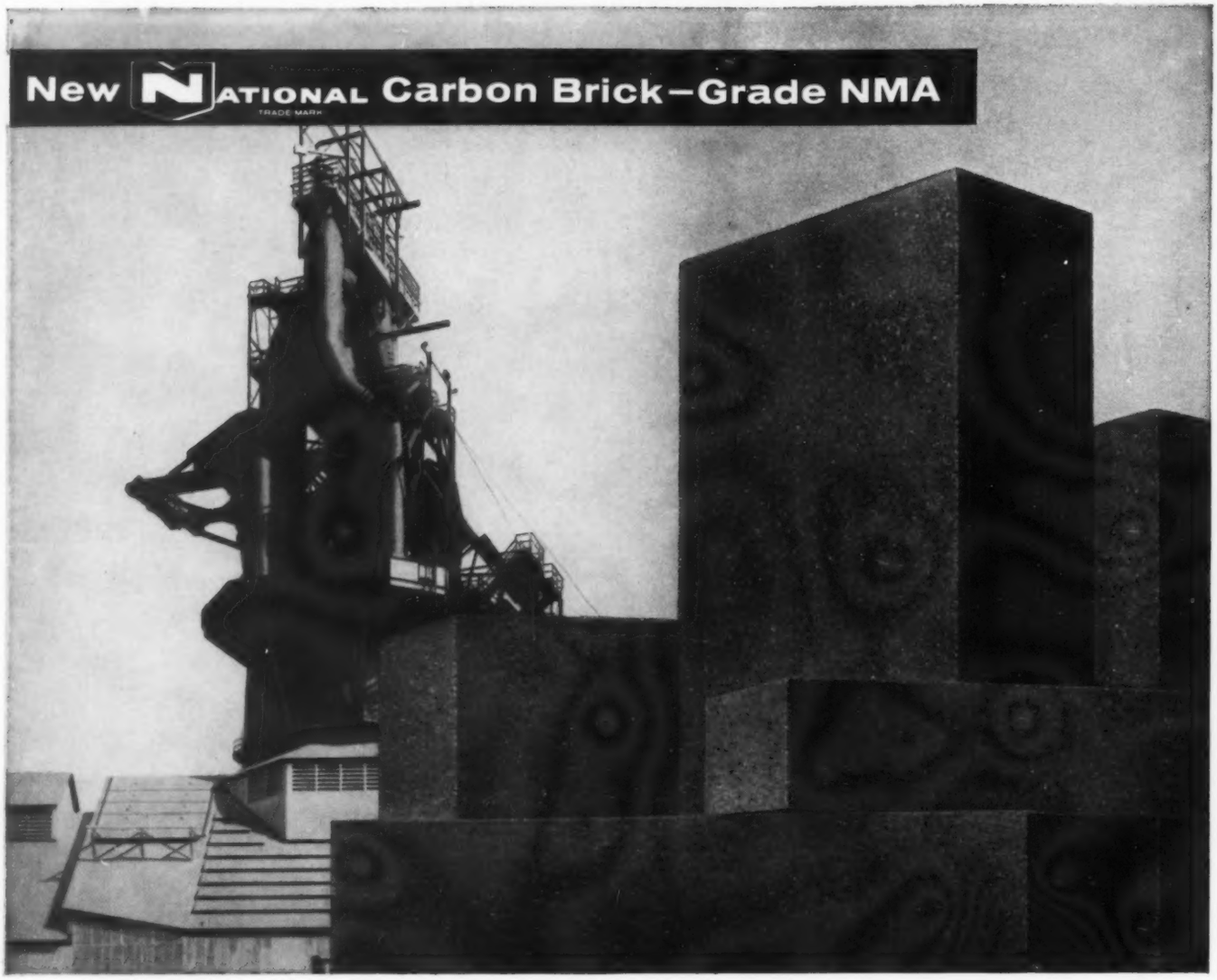


DOUBLE-EXTENDED WORM SHAFT



GEARSETS & MOUNTINGS





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This outstanding refractory material is especially designed for **Blast Furnace Linings.**

Grade NMA brick offers:

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Grade NMA brick is available from 4½" x 2½" cross section to 9" x 4½" cross section in up to 18" lengths.

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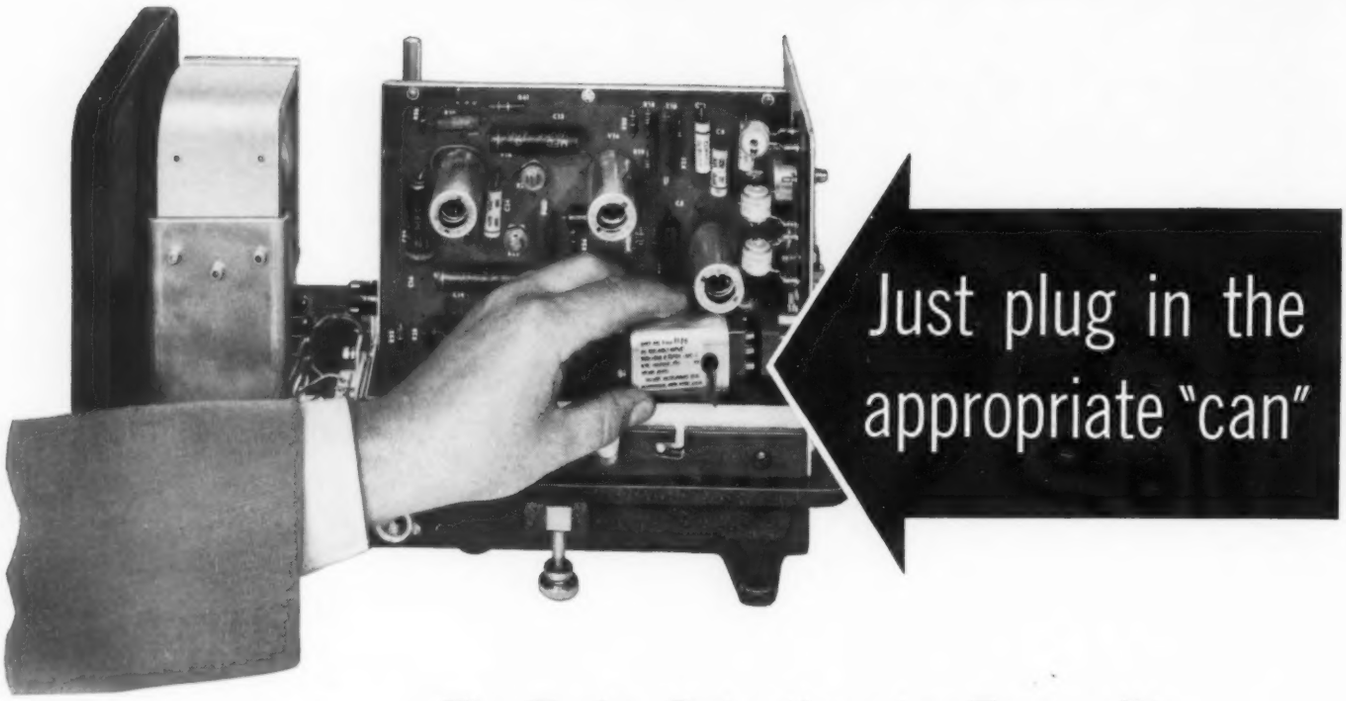
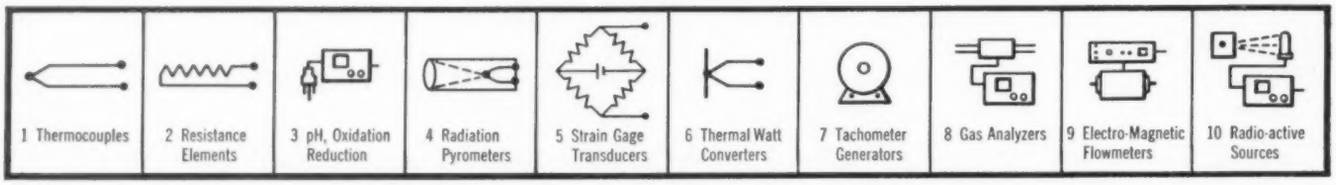
* ORIGINATORS AND LEADING PRODUCERS OF OPEN COIL AND SINGLE STACK FURNACES



. . . The Taylor Potentiometer Transmitter will receive signals from all these sensing elements



Designed to convert low voltage measurement signals (millivolts) to an electric and/or pneumatic output for controllers and receivers, the 700T Potentiometer Transmitter is exceptionally adaptable. Plug-in service "cans" mean that the instrument can be quickly converted for use with different primary elements by simply inserting an appropriate can. For thermocouple applications, reference junction compensation is always correct since it is part of the can.

The 700T Transmitter comprises two basic units — an Electronic Potentiometer Amplifier, the output from which may be transmitted to data processing or other electrically-actuated equipment; and an Electro-Pneumatic Transducer which converts dc current to a proportional air pressure. This output air signal can then be used with pneumatic measuring and controlling instruments. Both amplifier and transducer plug in—a great convenience, as well as a big saving on instrument down-time. The same amplifier is used with all sensing elements, minimizing inventories.

For processes requiring pneumatic receivers and controllers, and applications using miniature instrumentation, the 700T Potentiometer Transmitter is ideally suited. Ask your Taylor Field Engineer for detailed information, or write for **Bulletin 98262.** Taylor Instrument Companies, Rochester, New York, or Toronto, Ontario.

Taylor Instruments **MEAN ACCURACY FIRST**

AVERAGE LIFE: PB&B TUYERES WITH 90% MINIMUM CONDUCTIVITY

AVERAGE LIFE: TUYERES WITH 48%-72% CONDUCTIVITY

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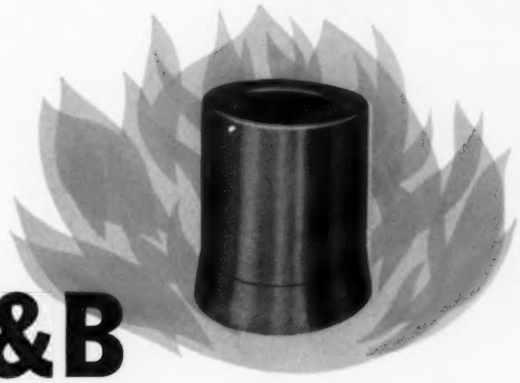

PB&B HIGH CONDUCTIVITY COPPER

lasts 62-85% longer
costs 20-34% less per day

Your furnace copper dollar buys more when you use PB&B high conductivity copper parts. Take tuyeres, for instance. This chart shows the actual service life of tuyeres of different conductivity copper under *equal operating conditions as measured in a recent test in a major steel mill.* PB&B high conductivity tuyeres far outlasted ordinary tuyeres . . . actually cost far less per day of service.

Only copper of the highest conductivity is used in PB&B components. Castings are virgin electrolytic copper, certified at 90% IACS minimum conductivity. Our forgings are OFHC* copper, guaranteed at least 98% IACS conductivity.

PB&B has developed unusual designs that utilize high conductivity copper to its fullest capability. Exclusive PB&B methods make possible copper castings with cast-in-place copper tubing** that boosts cooling efficiency. In our Hoffman bosh and stack plates, dual cooling chambers give maximum protection at hottest points; chambers can be operated independently of one another if necessary. We can supply conventional designs, too, in 90% minimum conductivity copper.

See how the PB&B combination of high conductivity and unique design can bring the economies of longer life and improved cooling to all your steel mill copper—*oxygen lance jet heads, roof coolers, monkeys, tuyeres, and bosh and stack plates.* Write today for data and for proposals on your specific requirements.

**Registered Trade Mark—American Metal Climax, Inc.*
***Patent applied for*

Furnace Products Division

PHILADELPHIA BRONZE & BRASS CORP.
22nd and Master Streets, Philadelphia 21, Pa.

a subsidiary of

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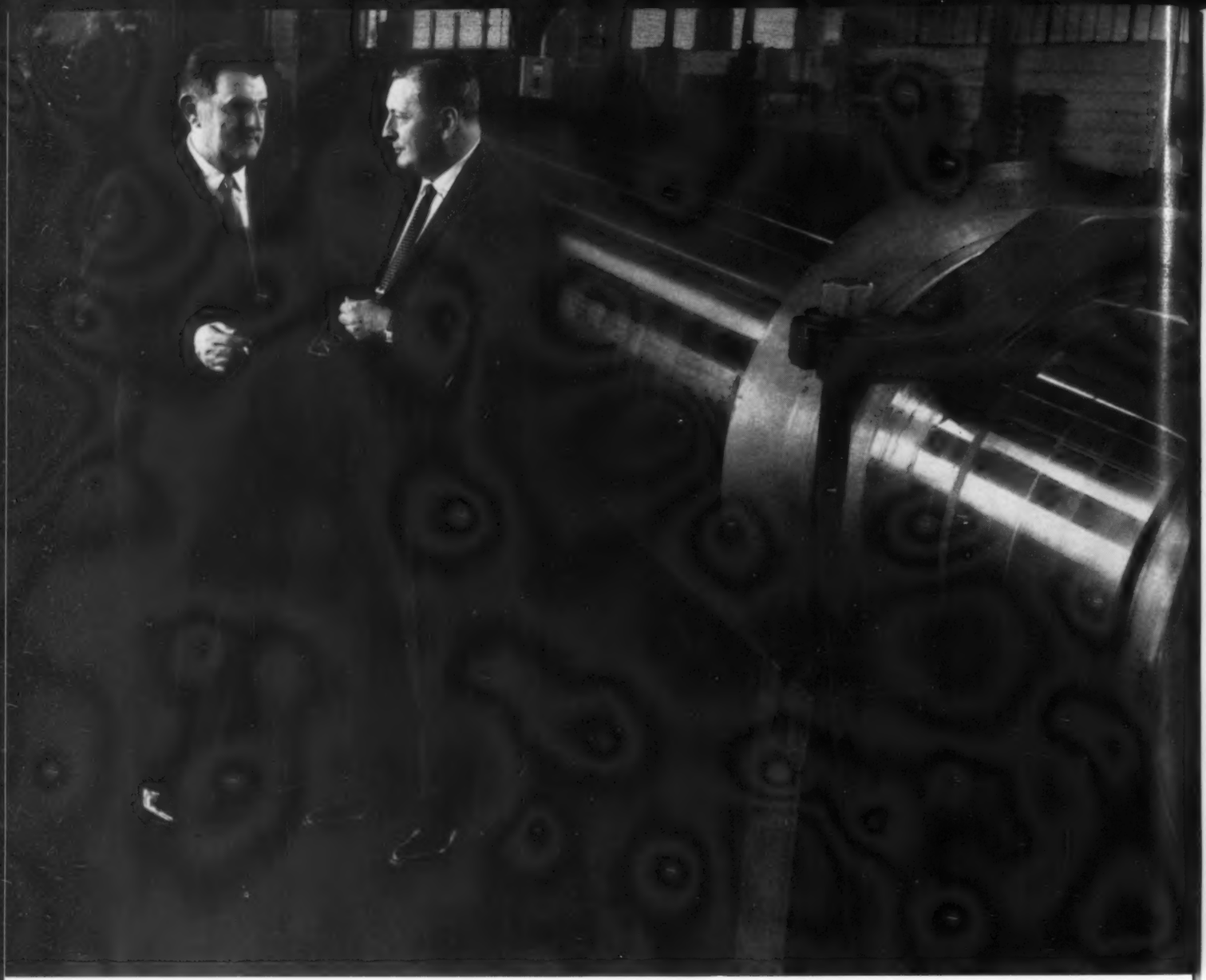
MALLORY



National's Deac Scholl, sales manager, and Bill Curran, works manager, talk rolls by one of the largest ever cast, a 38½x160" plate roll.

Another example of National Roll quality control

We "live" with your rolls <u>after</u> shipment, too

National Roll has only one business: rolls. This product concentration has enabled National to build a sales, service and production staff with specialized knowledge of roll making. Experienced men give every roll order placed with National "personalized" attention, all the way from consultation with the customer before the order is placed to follow-up on the roll's performance throughout its service life.

This emphasis on customer service is one reason for the confidence so many steel makers are placing in National as a supplier of steel, nodular iron and cast iron rolls.

A new brochure entitled "This is the New National Roll" explains many more of National's unique advantages as a roll supplier. We will be glad to send you a copy. It shows you why . . .

National's the growing name in rolls

NATIONAL ROLL & FOUNDRY DIVISION

GENERAL STEEL CASTINGS CORPORATION, Avonmore (Westmoreland County), Pa.

General Steel Castings Corporation, General Offices: Granite City, Illinois • Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.

Crops *and* Shorts

△ Third-quarter reports for the iron and steel industry are something less than inspiring, although most of the companies are in the black. Only United States Steel and National Steel made their dividends, but most companies held their dividend rate. A number of the smaller companies lost money.

△ In the midst of all the gloom, maybe we should remember that the U. S. steel industry is making about 100,000,000 tons of steel this year—and that is the sixth best production year we've ever had. Roger M. Blough, chairman of United States Steel, says 1960 will be the second best year for actual steel usage. Of course, complaints probably stem from the fact that 60,000,000 tons were made in the first half, while the last half looks like only 40,000,000 tons.

Anyone who has a speaking acquaintance with the steel industry knows that production varies considerably. But we seem to have developed a day-by-day philosophy, where everything is supposed to go on smoothly.

As a matter of fact, this live-for-today thinking often seems to pervade steel management. How often have projects—good, worthwhile projects that everyone knew were essential—been held up when business slackened, only to be rushed to completion, with overtime and extra costs, when business picked up.

A piece in Steel Facts, published by the American Iron and Steel Institute, says that steel companies have been pushing ahead with plans for improvements. Among projects announced were a new oxygen steelmaking shop, new coke ovens, blast furnace expansion, modernization of two tinplate plants, taconite plants, etc. Work is progressing on new galvanizing lines, sintering plants and strip mills. This proves that the industry is doing long-range planning.

Maybe what is lacking is short-range spending.

△ One of our misanthropic friends says marriage is like a tourniquet—it stops circulation.

△ Thomas F. Patton, president of Republic Steel Corp., sees the emergence of Russia on the world economic scene as a new threat to American industry, on top of continued competition from abroad. He said that, as a result of America's postwar rehabilitation programs, some of the largest steel plants in Western Europe and Asia have been made the equal of the best in America. Low labor rates abroad, coupled with the drive of labor unions at home for yearly increases in wages and benefits, have enabled foreign industry to undersell American producers in their own backyards.

△ Artificial obsolescence is a deterrent to customer satisfaction, the most basic factor in business, according to George M. Umbreit, president of the Maytag Co. He pointed out that any company could do a better job on product quality if its manufacturing processes, its assembly lines and its sources of supply were not upset every 12 months by an annual model change.

△ Plastic surgeons can do wonders. They can do anything with a nose except keep it out of other people's business.

△ John F. Smith, Jr., president of Inland Steel Co., told the American Institute of Steel Construction that the long range picture for the steel industry is favorable. He warned against undue optimism and undue pessimism in the short range swings. He said three new elements exist in the steel industry situation:

The shift from an extended period of relative steel scarcity to one of ample supplies.

Intensified competition from wood, concrete, paper, glass, aluminum and plastics.

Rising world output which has brought more competitors and greater steel availability into the international market.

Mr. Smith believes these problems will be met by accelerated research to reduce cost and develop new steel products, and by a new direction to steel company selling.

△ The combined net income of iron and steel companies and their subsidiaries averaged six cents of each dollar of income during the past 25 years, according to the American Iron and Steel Institute. For individual years, the rate of profit varied from a loss of 0.9 cent in 1938 to a maximum of 8.0 cents per dollar in 1940 and 1950. Also, individual companies had gains and losses which varied widely from the industry average.

Of the average six cents earned, 3.1 cents went to the industry's stockholders and 2.9 cents went back into the business.

Taxes took 7.7 cents of each dollar, employment costs 35.8 cents, and materials supplies, freight and other services 45.3 cents. Depreciation, depletion and amortization cost 4.7 cents per dollar and interest about 0.5 cent.

△ A friend who just lived through it says the only voice a man has in the decoration of a home is the invoice.

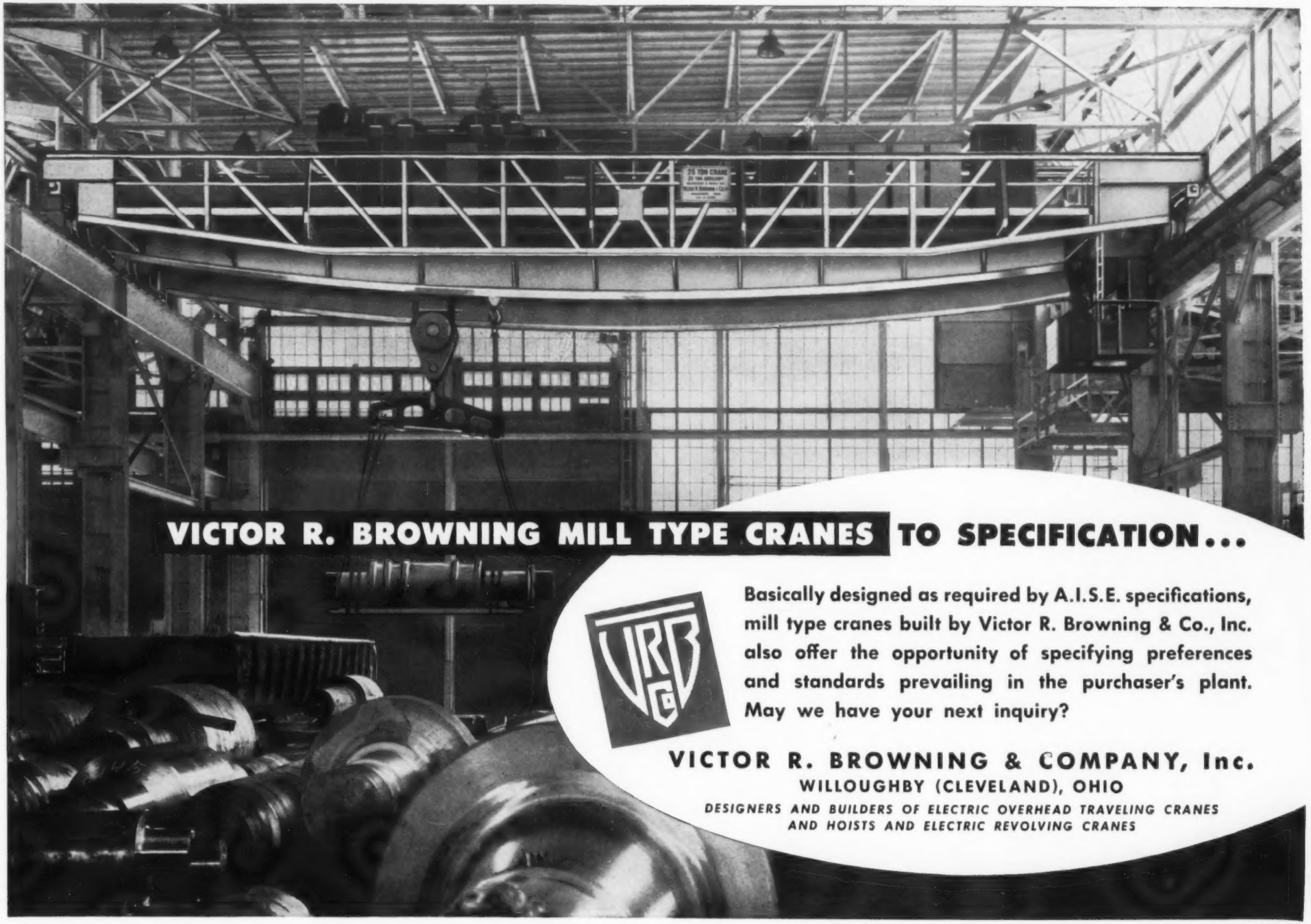
△ Figures released by the American Iron and Steel Institute show that wage supplements (vacations, pensions, insurance, etc.) made up 18.6 per cent of total employment costs in 1959. Supplement costs in 1959 totaled $543,100,000.

△ W. Trinks writes: "In 1935, the pay for writing a technical book was minus three cents an hour. Now, it is minus nine cents per hour."

That's inflation, prof.

△ When India's three new steel plants (at Bhilai, Rourkela and Durgapur) are completed, the country will produce nearly 6,500,000 tons of steel annually. A fourth new plant of 1,000,000 tons per year capacity has been proposed, to be located at Bokaro.

△ August Thyssen-Hutte A.G., a major steel producer in West Germany, is planning a new semi-continuous hot strip mill, which in turn will require expansion of blast furnace and oxygen steelmaking facilities. Thyssen's fiscal 1960 production totaled 3,388,000 tons, 27.4 per cent more than in 1959.



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in 1960...

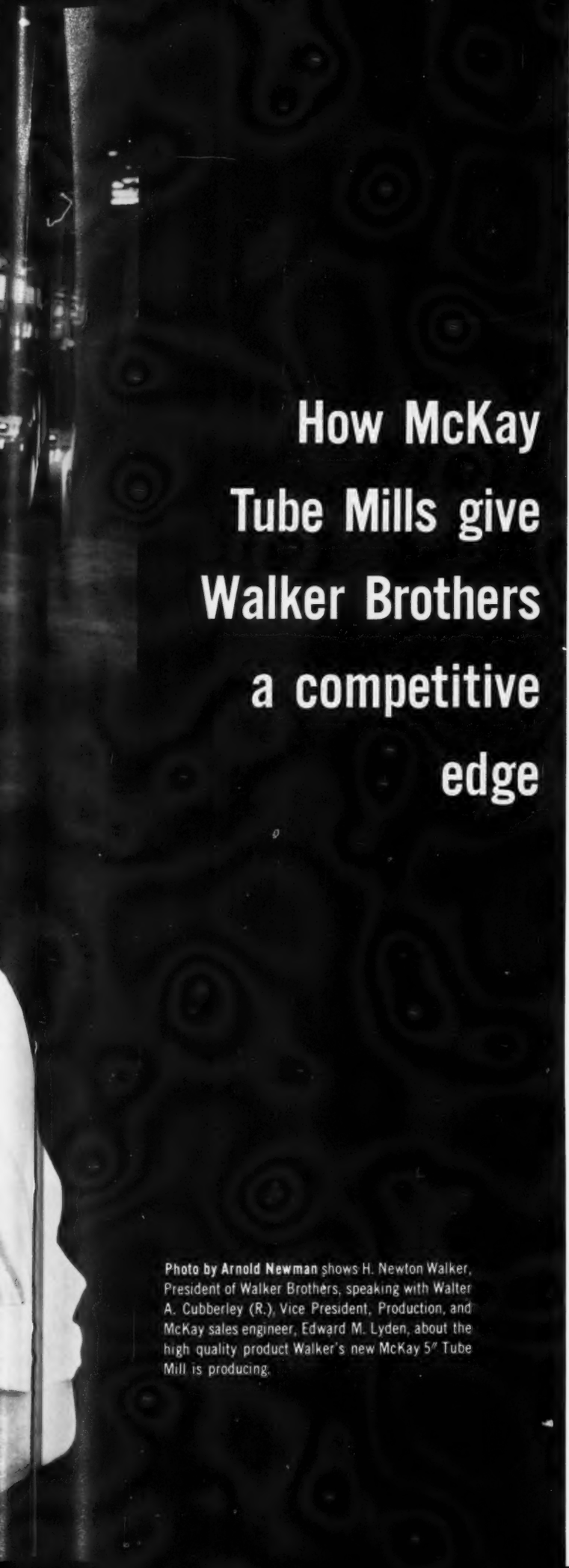
LOOK TO

McKAY MACHINE

FOR PROGRESS IN METAL PROCESSING

FOR EXAMPLE—McKay Pipe and Tube Mills are recognized to be the best conceived and finest constructed machines of their kind. On the next two pages H. Newton Walker, President of Walker Brothers, Conshohocken, Pa., gives a typical user reaction.

MCKAY



How McKay Tube Mills give Walker Brothers a competitive edge

Photo by Arnold Newman shows H. Newton Walker, President of Walker Brothers, speaking with Walter A. Cubberley (R.), Vice President, Production, and McKay sales engineer, Edward M. Lyden, about the high quality product Walker's new McKay 5″ Tube Mill is producing.

"Our new McKay 5″ Tube Mill enables us to extend our production range to the larger sizes of Walkerduct and steel tubing. The mill affords close manufacturing tolerances and improved control over production schedules," says H. Newton Walker, President of Walker Brothers, Conshohocken, Pa.

High Quality Product—Walker Brothers has been a primary supplier of high quality electrical distribution materials to the commercial and industrial construction industry for fifty years. "Walker of Conshohocken" products include building wire, power and control cables, mechanical steel tubing, steel electrical metallic tubing, rigid steel conduit and underfloor raceways.

"This is the third McKay Tube Mill we have installed since 1951 to increase our capacity to manufacture conduit and raceways," continues Mr. Walker. "Each of these mills," he says, "has turned out a product consistent with our high standards of manufacture."

Better Production Economies—Walker Brothers has, in addition to the new McKay 5″ Tube Mill, two 3″-capacity McKay mills equipped with strip looping and welding equipment. These mills are generally used to produce ½″ through 2″ thin wall conduit on a continuous basis at a speed of 150 feet per minute. The new 5″ mill also operates at 150 F.P.M. and at that speed can easily produce Walker's line of 6.5″ x 1.5″ x .076″ rectangular raceway.

Mr. Walter Cubberley, Vice President, Production, states: "We have been most satisfied with the performance of this equipment. Performance of the McKay mill has more than met our expectations regarding versatility and cost savings."

Low Maintenance Cost—"There's something to be said for the design of this equipment, too," he says, "in that maintenance is, and has been, satisfactorily low regardless of the age of the machinery."

"This is very solid equipment, including the welder. In fact, I would say these are the best mills we could have selected for our type of operation," Mr. Cubberley concludes.

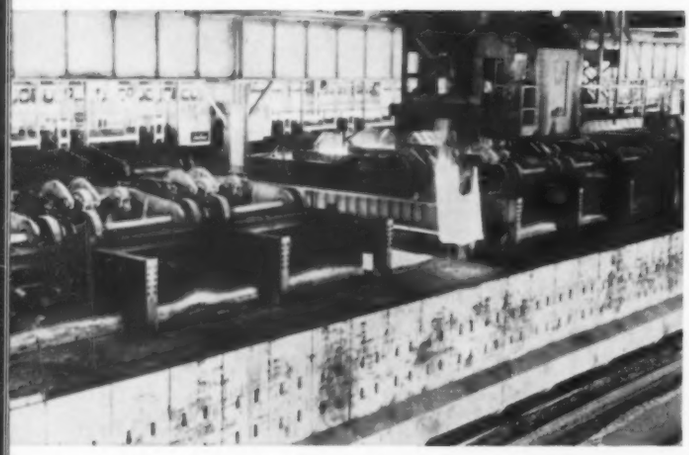
McKay Machine designs and builds electricweld tube mills for high speed production of ferrous and nonferrous welded tubing up to 20″ in diameter. The experience of nearly 25 years of pioneering in the design of tube making equipment is behind each modern McKay Tube Mill.

Write for literature, or send a description of your needs for prompt quotation to McKay Machine Company, Youngstown 1, Ohio.

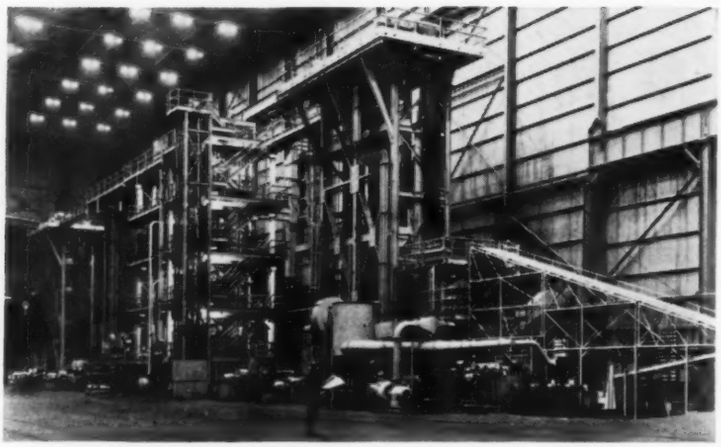
LOOK TO

McKAY MacK MACHINE

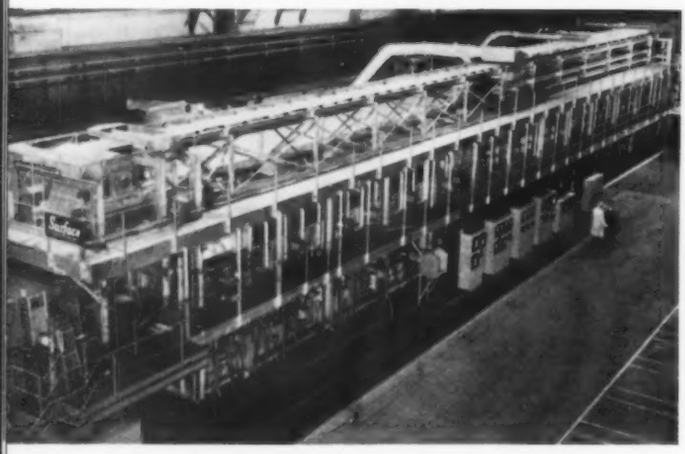
FOR PROGRESS IN METAL PROCESSING



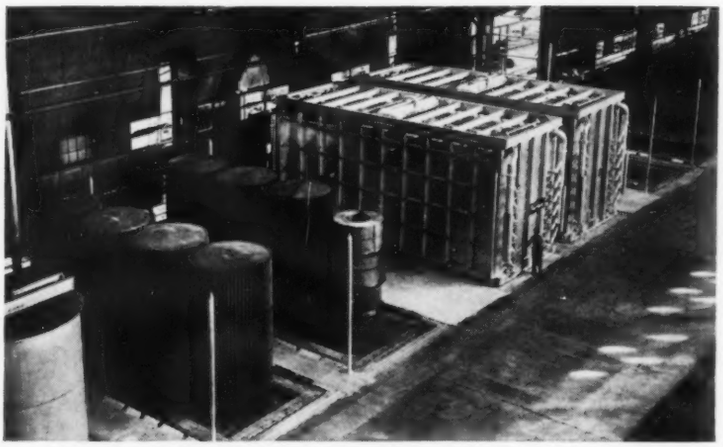
48 soaking pits installed at one time.



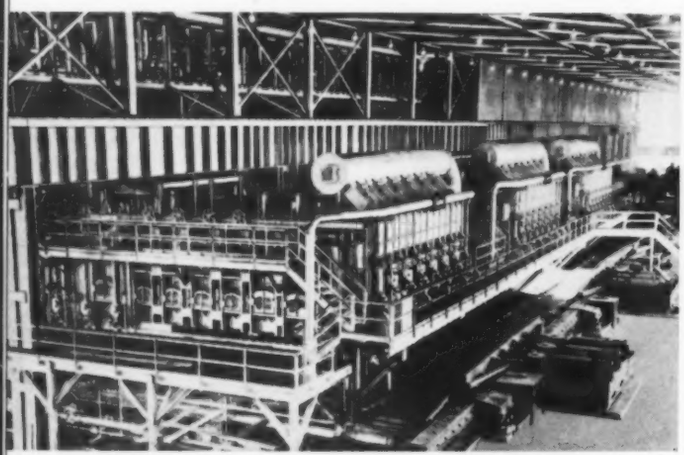
Continuous tin plate annealing line.



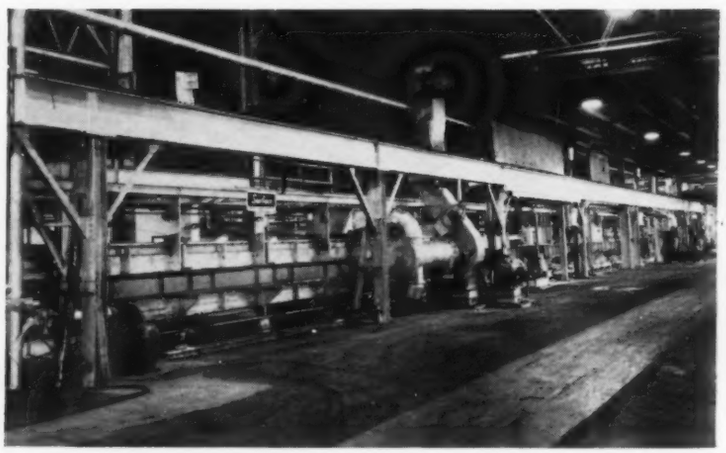
Normalizing line for enameling strip.



Multiple-stand annealing covers.



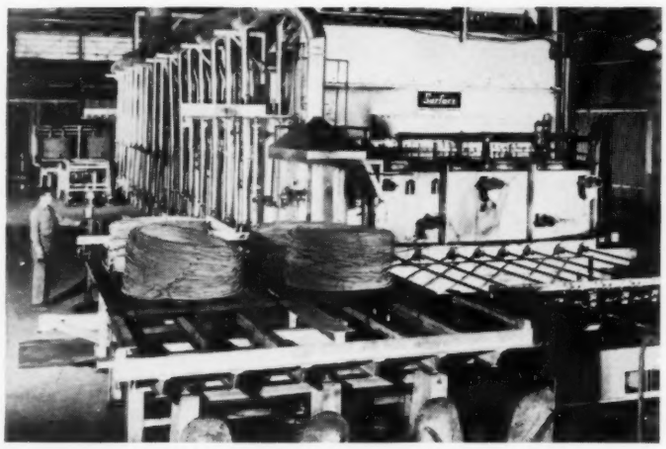
World's largest slab-heating furnaces.



Continuous strip galvanizing line.

Worldwide engineering and manufacturing facilities through associates in Australia

Single-stand radiant tube annealers.



Annealing, carbon restoration furnace.

Car-bottom rod and bar furnace.

PROVING GROUNDS

for steel profits

Surface Combustion's proving grounds—a few of which are shown at the left—include virtually every rolling mill in North America plus a considerable number abroad.

You can sample here the variety of Surface equipment which has passed the toughest tests on the steel mill floor: checked out for quality, shaken down for reliability, and—most important to you—proved out for profitability.

With internal costs and external competition on the rise, it will pay you more than ever before to specify the services and equipment of a company which has repeatedly passed the tests in steelmaking's ultimate proving grounds. Surface Combustion, 2404 Dorr Street, Toledo 1, Ohio.

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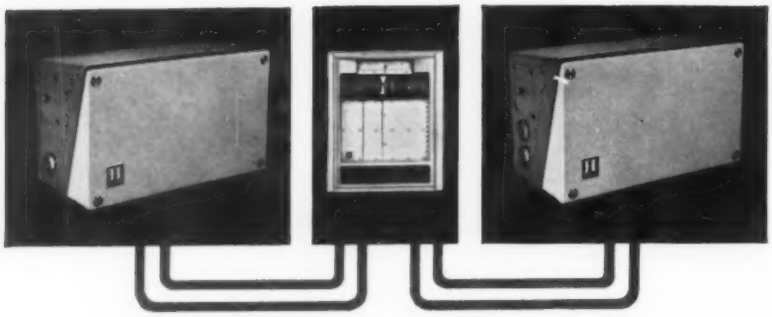
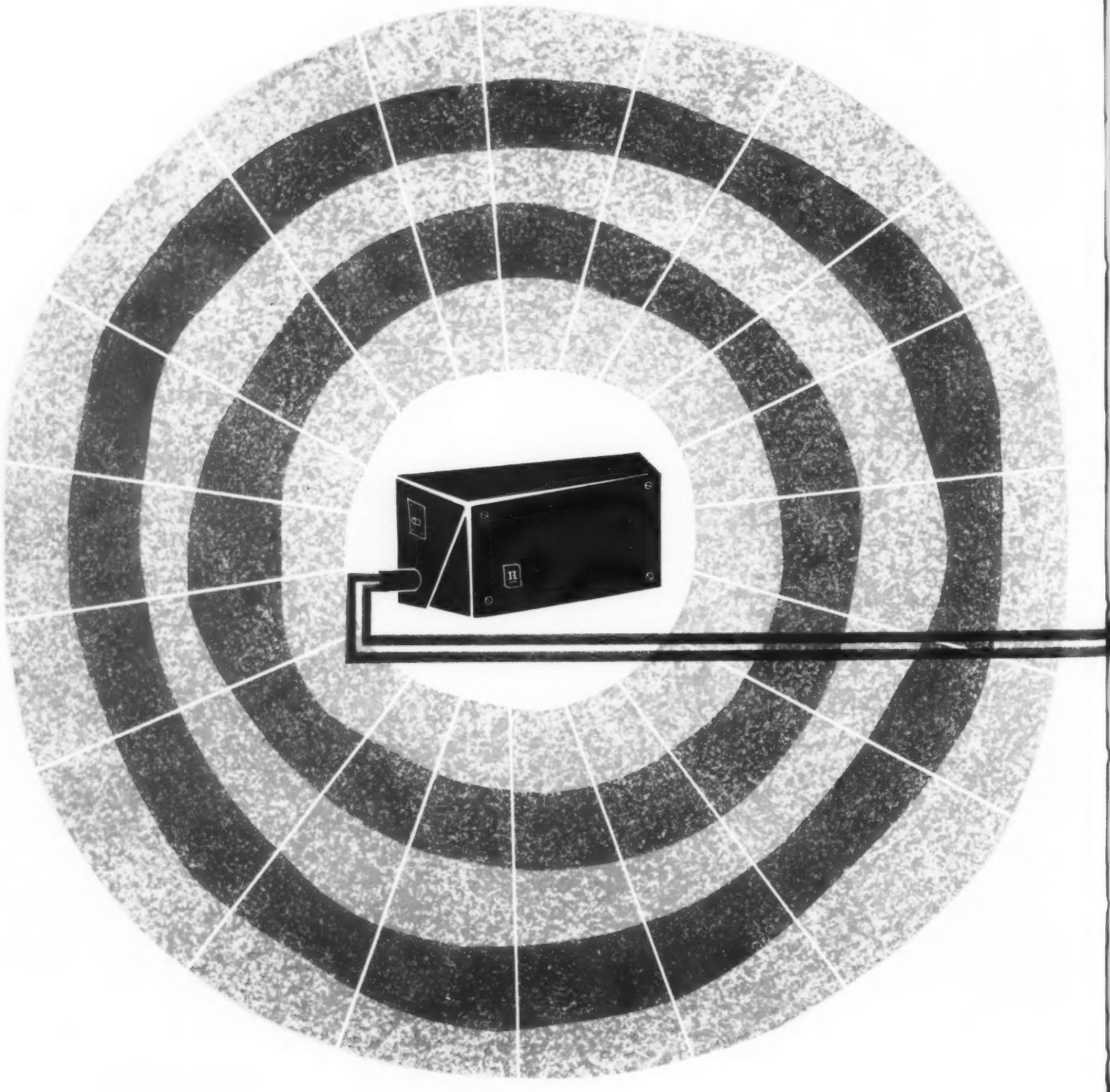


***ElectriK Tel-O-Set*—the true 2-wire system**



TAKING THE HEAT OFF FIELD-MOUNTED TRANSMITTERS

The *ElectriK Tel-O-Set* System takes the heat off field-mounted instruments by *eliminating heat-generating tubes and power packs.* There's no external power required at any *Tel-O-Set* field-mounted instrument. The line power connection is made only at the receiver.

Tel-O-Set field-mounted instruments operate on a low calorie diet of 4-20 milliamps . . . less than 0.6 watts. A simple two-wire line connects the field-mounted instruments with the control room. The two wires carry the control signal as well as the power. The d-c transmission avoids stray pickup and phasing problems . . . eliminates the need for shielding the line.

The 4-20 milliamp signal range of the system gives a live zero and permits the use of the most reliable transistors available. These d-c signals can be fed into data handling systems and millivolt-actuated instruments . . . can be easily transduced to a standard 3-15 psi pneumatic signal to operate existing pneumatic systems.

The basic circuit used in *Tel-O-Set* transmitters, receivers, controllers and other instruments has been thoroughly proved in thousands of applications in the last five years. This circuit uses a force-balance feedback system to increase the accuracy and the dynamic response of the system by decreasing hysteresis effects and sensitivity to changes in ambient conditions.

Take a new look at your control applications with the *ElectriK Tel-O-Set* System in mind! Get complete technical data from your local Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Mass.

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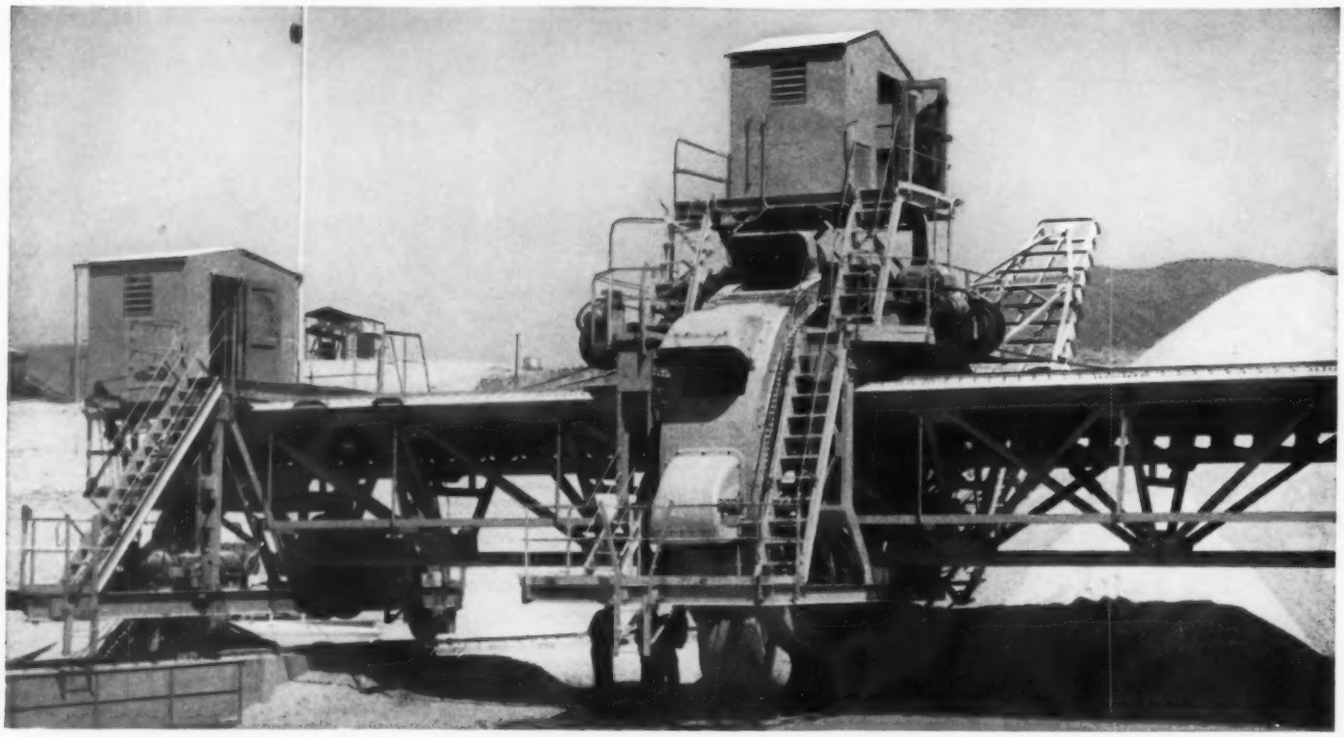


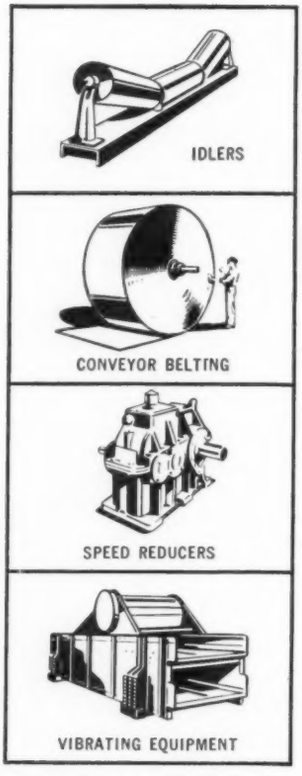
BIG WHEEL

It blends...it reclaims...it ends inefficiencies of selective mining

As part of a new H-R Rotary Bucket Wheel Blending and Reclaiming System, this giant 3-story wheel is capable of processing efficiently a broad range of materials . . . especially where more than one of the following typical situations exist:

1. Engaged in selective mining
2. Unable to comply with specifications
3. Too much coarse or fine material in feed
4. Storage pile requirements range 50,000 tons and over
5. Two or more types of raw material to blend for chemical compounding.

For full details consult your H-R representative, or write Hewitt-Robins, Stamford, Connecticut. Ask for Bulletin 11-50.



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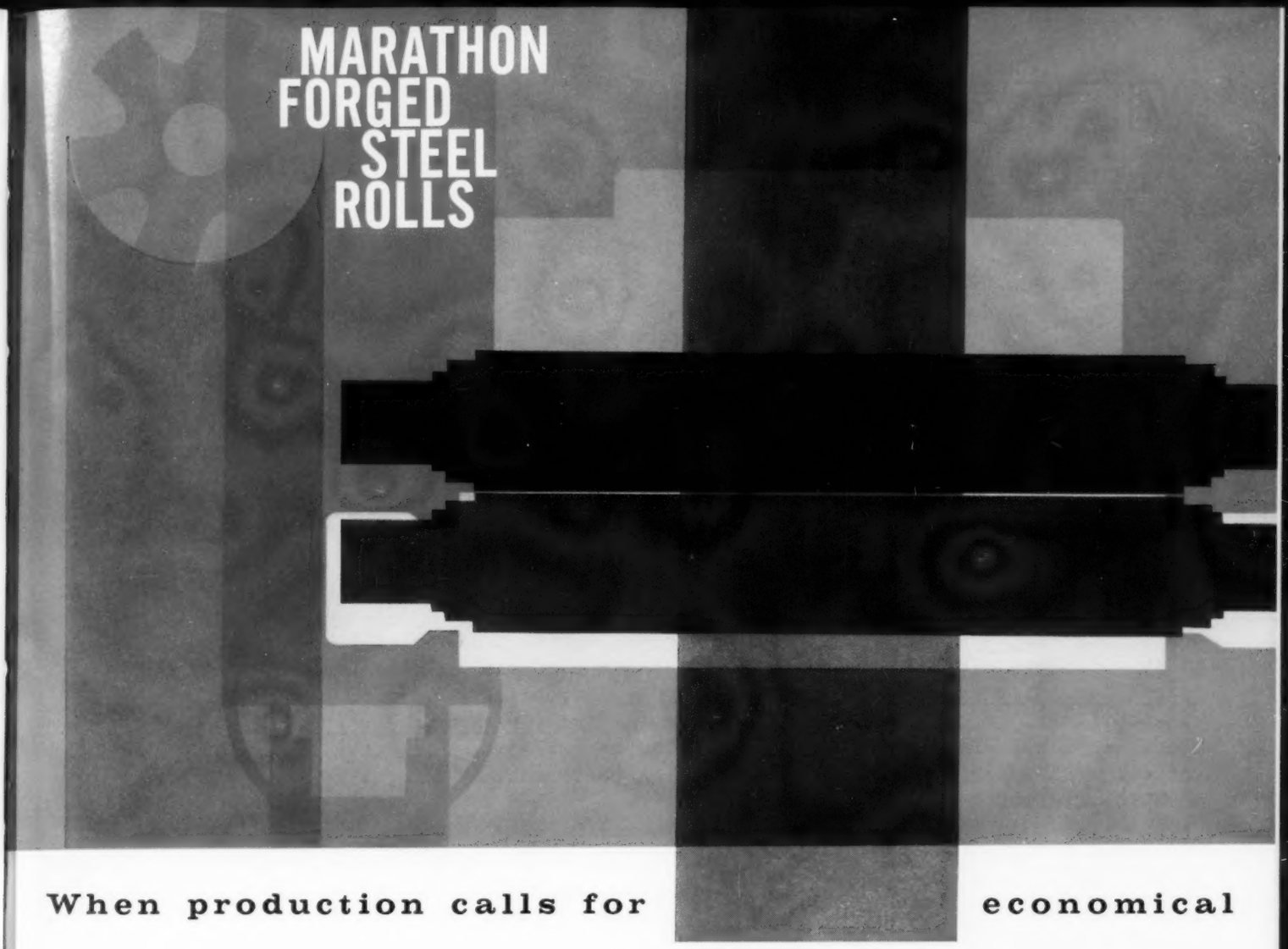

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METALGRAMS

UNION CARBIDE METALS

. . . news about "Electromet" ferroalloys and metals

NOVEMBER, 1960

AN EFFICIENT BLOCK -- Why is silicomanganese the most popular blocking alloy in the steel industry today? It dissolves 50 per cent faster than separate silicon and manganese additions, giving faster blocks and shorter blocking times. Its low-carbon content allows higher tapping carbons, reducing furnace time and also aiding steel cleanliness. Since silicomanganese is a more powerful deoxidizer than straight silicon blocks, it gives tighter blocks that last longer. Finally, silicomanganese provides low-cost silicon and manganese, reducing blocking costs to a minimum.

* * *

BETTER CONTROL, TOO! -- Results of hundreds of open-hearth production heats show that a silicomanganese block gives better control of carbon content and alloy additions. Off-grade heats for carbon and manganese have been shown to be lowest for silicomanganese compared to a pig ferrosilicon or a 50 per cent ferrosilicon block. Also, silicomanganese gave a higher manganese recovery than other blocks when all the manganese was added to the furnace. For details, write for the article, "Silicomanganese Improves Blocking Performance," in the Fall 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

LOWER COSTS FOR STAINLESS STEEL -- Another manganese-silicon alloy -- ferromanganese-silicon -- is saving stainless steel producers thousands of dollars per year. Used for slag reduction and manganese additions, ferromanganese-silicon is replacing other low-carbon manganese sources. Savings per ton: $0.75 to $1.75 for type 300 stainless grades and $4 to $9 for type 200 grades. Some stainless producers have also found that ferromanganese-silicon produces cleaner steels. Write for F-20,093 for further information.

* * *

BUILDING BIGGER MARKETS -- "Your man's practically a member of my staff," a president of a steel firm said of one of UCM's market development specialists. These men work with steel producers to develop new markets and expand old ones. Primarily, they promote the use of stainless steel and titanium (including castings) in transportation, architecture, process industries, and consumer goods. More details can be obtained by writing for the article, "Men, Metals, and Markets," in the Spring 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

PRODUCTS WITH A SPLIT PERSONALITY -- Several "Electromet" alloys and metals are used in both metals and chemicals. Silicon metal -- an important alloy in aluminum and copper -- is a key raw material for silicones. Vanadium oxide -- used in tool and constructional steels -- is a catalyst in the production of adipic acid, sulfuric acid, maleic anhydride, and phthalic anhydride. It also gives special colors to glass and ceramics. Finally, "Elmang" electrolytic manganese -- high-purity manganese for stainless steel, deep-drawing steels, copper and aluminum -- is a catalyst for adipic, terephthalic, and acetic acids. Write for the article, "Products with a Split Personality," in the Spring issue of UNION CARBIDE METALS REVIEW.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Ave., New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

"Elmang," "Electromet," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

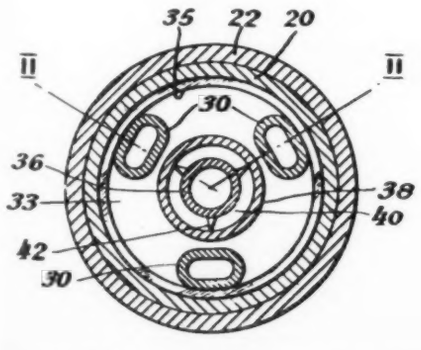
Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period May 24, 1960 to June 28, 1960

GUN ASSEMBLY USED IN AN OPEN HEARTH FURNACE

△ U. S. 2,937,864, issued May 24, 1960 to Arthur J. Kesterton and assigned to The Steel Company of Wales Ltd., provides an apparatus for the injection of oxidizing gases in the form of a jet of near sonic speed on to the surface of molten iron or steel in open-hearth furnaces, tilting or stationary, and mixers, both of the "active" and "inactive" types.

The use of oxidizing gases consisting of oxygen or oxygen-enriched air produces under certain circumstances considerable quantities of brown fumes when impinged upon the surface of molten steel or iron, especially if the bath contains substantial quantities of carbon. The brown fumes so produced are a considerable nuisance and it has been discovered that the mixture of steam with the oxygen greatly reduces the amount of brown fume produced. The present invention, therefore, has for an object the provision of a gun assembly, the construction of which allows for the ready mixing of oxygen and steam, and control of the ratio so as to suit the composition of the charge.

Figure 1



As shown in Figure 1, an essential feature of the gun is that the oxygen is carried down the annular space 40 formed between the central steam pipe 36 and the inner surface of the oxygen pipe 38. Thus it is the oxygen pipe 38 which is in contact with the water jacket, so that the oxygen in the annular space 40 acts as an insulator to the steam pipe 36, to minimize loss of heat from the steam to the water jacket which would otherwise occur, causing condensation of steam, and loss of pressure.

The cluster of water cooling pipes 30 are oval in shape, having been made in this form by flattening ordinary circular steel pipe, in order to obtain a sufficiently large cross-sectional area of pipe to carry the necessary water to the tip of the nozzle end of the gun, and yet to incorporate these pipes, together with the central steam and oxygen pipe assembly in an outer pipe 20 of the smallest possible diameter, thus minimizing heat losses from the furnace and reducing the size of the hole required through the roof.

TREATMENT OF WASTE PICKLE LIQUOR

△U. S. 2,939,763, issued June 7, 1960, to Franklin D. Cooper and assigned to Otto Construction Co. relates to the production of iron-free ammonium sulphate and iron carbonate through the utilization of gases essentially comprising carbon dioxide and ammonia for the treatment of spent or waste pickle liquor.

As indicated in Figure 2, a gaseous mixture comprising essentially carbon dioxide and ammonia is passed in counter-current contact with a modified waste pickle liquor through at least two distinct zones or chambers in reactor 32. In the first of these zones or chambers, the alkaline section, the gas stream encounters and reacts with an alkaline feed liquor comprising partially treated waste pickle liquor containing ammonium sulphate and soluble iron salts in the form of ferrous ions, sulphate ions and free ammonia. In this zone, the ammonia and carbon dioxide go into solution as ammonium carbonate and ammonium bicarbonate, which react with the soluble ferrous sulphate and other soluble iron compounds to form a precipitate or iron carbonate. Traces of iron hydrate are formed either by virtue of the presence of up to 4 per cent oxygen in the contacting gas or by the decomposition of traces of ferric carbonate which may form. The iron carbonate is sparingly soluble, and is readily removable.

The gas stream is then passed into a second zone or chamber which is a predominantly acidic zone where all of the remaining ammonia is scrubbed from the gas with a mixture of spent pickle liquor and recycled partially neutralized pickle liquor to form ammonium sulphate which remains in solution. The gaseous

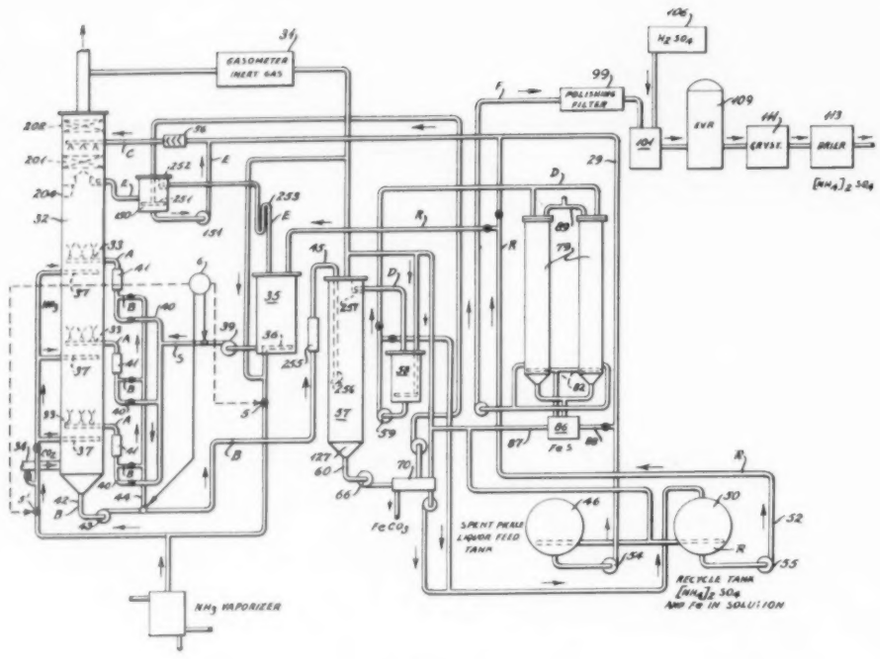
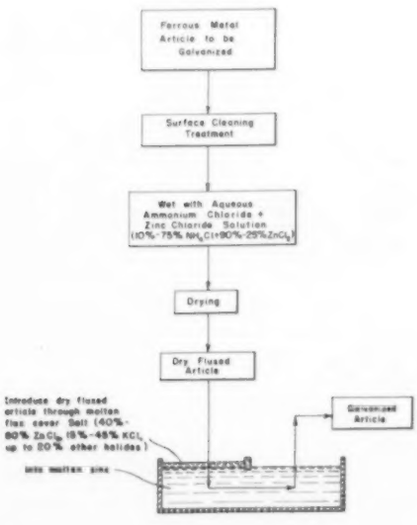


Figure 2

effluent from the acidic zone contains from 3 to 5 per cent by volume carbon dioxide. The iron carbonate, with traces of iron hydrates, at the most less than 2 per cent by weight of iron hydrates, is separated from the liquid effluent from the first gas contact zone. After removal of these insoluble materials, the liquor may be subjected to further refining treatments, in order to remove any remaining traces of iron. A portion of the liquid effluent from the first or alkaline chamber is recycled with a feed stock liquor to form an alkaline feed liquor for the initial contact area, where the recycled effluent contributes to the volume of the liquid, adjusts the pH of the alkaline feed liquor to between 5.5 and 9.5, and enhances the liquid-gas contact in that portion of the process. The feed stock liquor is obtained by the neutralization of the free acid equivalent in spent pickle liquor with ammonia.

Figure 3


Ferrous Metal Article to be Galvanized
Surface Cleaning Treatment
Wet with Aqueous Ammonium Chloride + Zinc Chloride Solution
Drying
Dry Fluxed Article
Introduce dry fluxed article through molten flux cover
Galvanized Article

HOT DIP GALVANIZING PROCESS

△U. S. 2,940,870, issued June 14, 1960, to Allen T. Baldwin and assigned to Hanson-Van Winkle-Munning Co., relates to galvanizing ferrous metal articles by the hot dip method, and is particularly directed to the provision of an improved procedure for fluxing the ferrous metal to insure formation of a continuous, tightly adherent film of zinc. As shown in Figure 3, the process involves wetting the ferrous metal with an aqueous solution of a flux of ammoniacal zinc chloride and drying the solution to form a thin deposit of the flux on the article, after which the article is dipped in a molten bath of zinc covered by a fluid salt blanket which is at all times essentially free of ammonia (including ammonium salts).

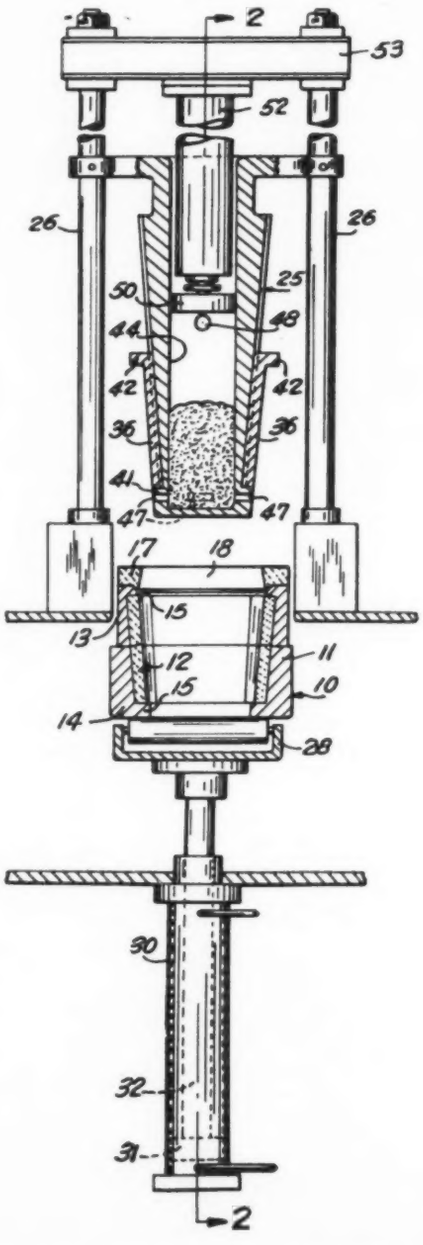
PROTECTIVE LINING FOR A HOT TOP

△U. S. 2,942,319, issued June 28, 1960, to Benjamin F. Anthony and assigned to Oglebay Norton Co., provides a method and apparatus for applying a protective lining to the inner surface of a hot top.

As shown in Figure 4, the apparatus for applying a protective layer of refractory material to the fire brick lining 12 consists of a mandrel 25 having the shape of the opening in the hot top and adapted to be telescoped within the hot top 10 to provide with the interior walls of the hot top a mold for forming the protective layer.

The mandrel 25 is supported in a fixed vertical position by vertical stanchions 26. The stanchions 26 support the mandrel 25 in a position above a power driven conveyor which moves the hot top 10 into a position where the hot top and mandrel 25 may be moved into telescoped relationship. The power driven conveyor includes a section

Figure 4



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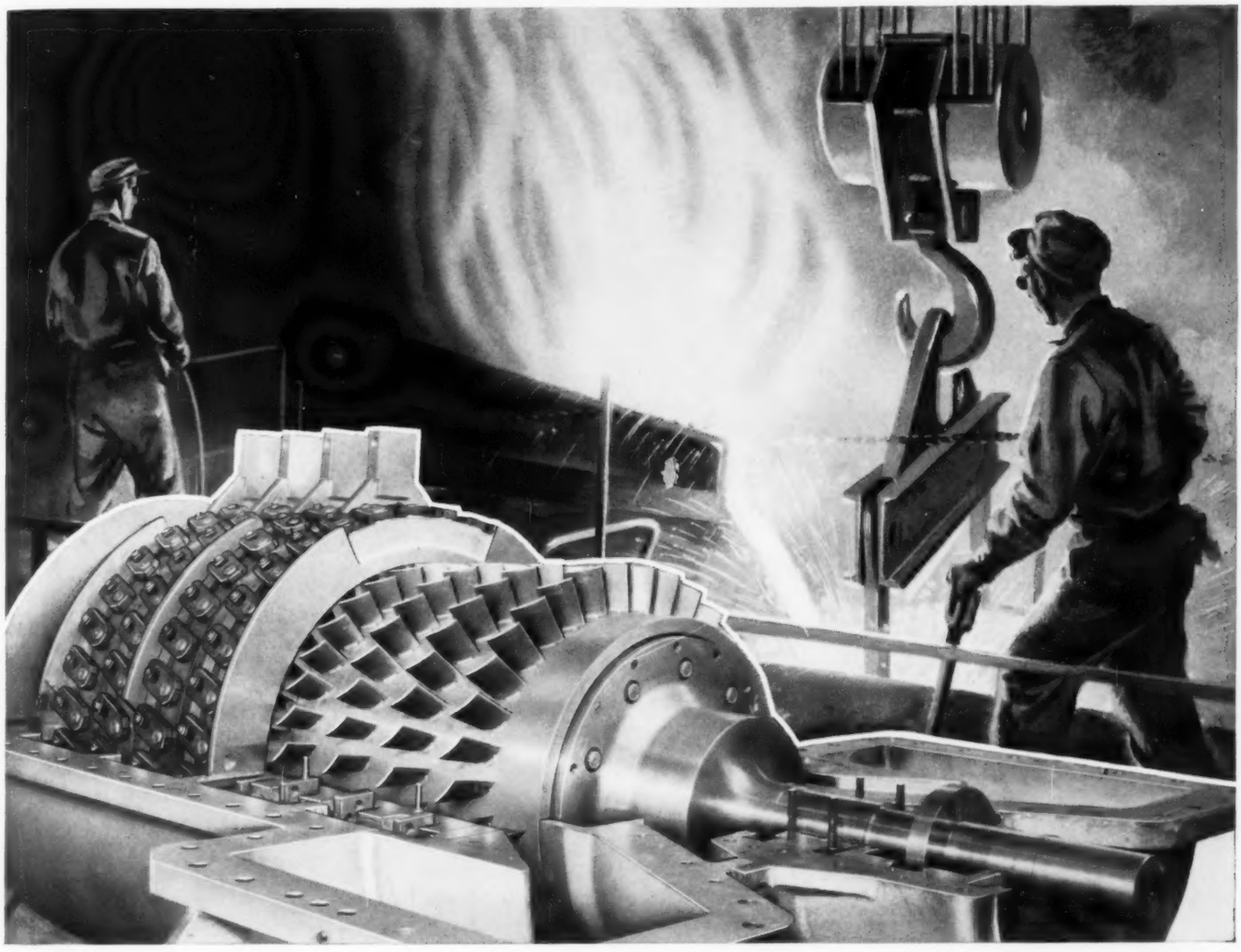
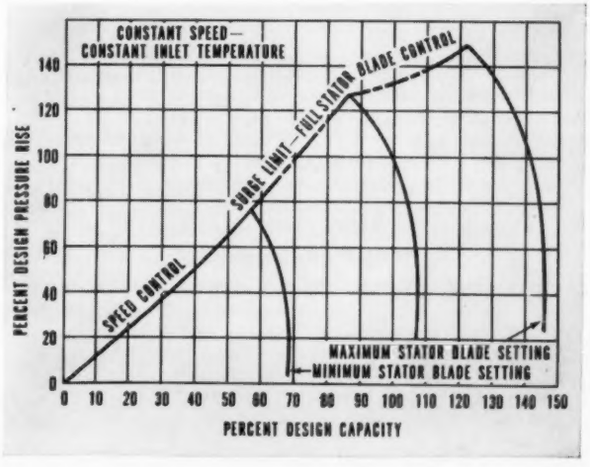


U. S. Steel Orders World's First

Adjustable Blade Axial Compressor for Blast Furnace Duty

Scheduled for 1961 installation at the Edgar Thomson Works, this 165,000 cfm, 50 psig. axial compressor is designed to provide wide operating range, lower steam requirements and save space. Fully adjustable stator blades will allow U. S. Steel to vary capacity while the machine is operating, to meet a broad range of operating conditions. Characteristics inherent in axial design will provide them with relatively constant volume when increased pressure is required, and will reduce steam requirements by 10% or more. But that's not all — U. S. Steel will receive additional savings in handling, foundation and space costs because this axial compressor will be *half* the diameter and *half* the weight of an equivalent centrifugal compressor.



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28 immediately below the mandrel 25. The section 28 is moved vertically by the operation of a hydraulic ram 30.

The hot top to be treated is placed on the conveyor and is moved thereby onto the movable section 28. After the hot top is on the section 28, the ram 30 elevates the section 28 and the hot top to dispose the mandrel 25 and the hot top 10 in telescoped relationship.

The exterior configuration of the mandrel 25 conforms to the interior configuration of the hot top 10 and when the mandrel 25 and the hot top 10 are disposed in telescoped relationship, a space is provided between the mandrel 25 and the hot top. This space forms the mold cavity for receiving the plastic refractory material.

The mandrel 25 is provided with a longitudinally extending bore 44. The bore extends to a point adjacent the lower end of the body member 35 and communicates with passages 47 that extend from the opening 44 through the mandrel and opens into the space between the mandrel and the fire brick lining when the hot top and mandrel are telescoped. The refractory material to be applied as a protective layer enters the mandrel through a port 48 communicating with the bore 44. The material may be supplied by any suitable means connectible to the port. After entering the bore 44 the refractory material is forced from the bore 44 by a plunger 50 disposed in the bore 44 and connected to the piston rod 51 of a fluid pressure cylinder 52 supported by a crosshead 53 extending between the upper ends of stanchions 26. When fluid pressure is applied to the upper end of the cylinder 52, the plunger 50 is moved downwardly to force the refractory material in the bore 44 out through the passages 47 to fill the space between the mandrel 25 and the fire brick lining 12.

MEASURING THE MELT TEMPERATURE OF AIR-BLAST CONVERTERS

△U. S. 2,942,470, issued June 28, 1960, to Ludwig A. von Bogdandy and Heinz-Dieter Pantke, assigned to Huttenwerk Oberhausen A.G., provides an apparatus for measuring the average temperature of the melt in a converter, without reliance on radiation intensity.

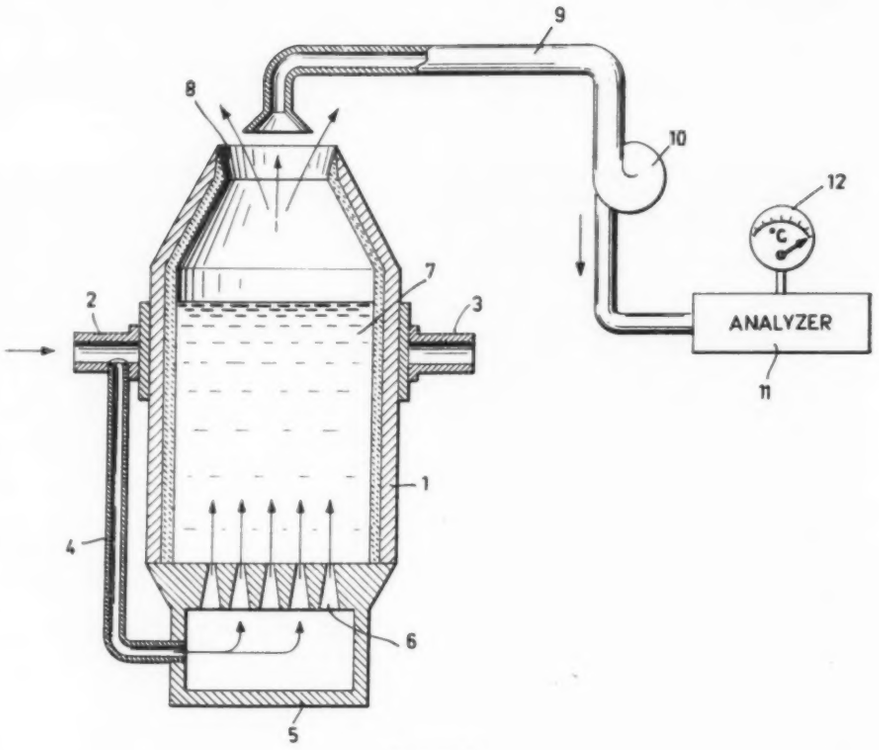

Figure 5

A feature of the invention resides in analyzing the density of specific melt or slag components in the vapors leaving the bath. It has been found, in accordance with this invention, that in the course of a blow there occurs in the converter a continuous vaporization and that the vapor densities of the components referred to are directly related to the temperatures of the melt and of the slag, respectively. More specifically, it has been determined that the densities of the melt components (e.g., iron, manganese and phosphorus) are proportional to the temperature of the combustion zone, which is somewhat higher than the average bath temperature, and that the densities of the slag components (e.g., CaO, Na_2O and K_2O) are directly proportional to the slag temperature which in turn is identical with the average temperature of the melt. For this reason, an advantageous feature of the invention resides in the separation of entrained dust particles from the vapors and in the analysis of these particles to determine their content of the slag components.

In Figure 5 there has been shown a converter 1 rotatably mounted, in bearings not shown, by means of trunnions 2 and 3. The left-hand trunnion 2 forms part of the conduit for an air stream which passes through a duct 4 into a wind box 5 and then, by way of tuyeres 6, into the interior of the converter 1 containing the bath 7.

Above the mouth 8 of the converter there is positioned the intake end of a suction pipe 9 which draws off some of the vapors rising from the bath 7. This is accomplished by means of a pump 10 which may also include a separator for removing the entrained solids from the vapor stream. The vapors and/or the dust particles are then fed to an analyzer 11 which controls a temperature indicator 12.

The analyzer 11 may be one of several devices well known per se. Thus, it may comprise calorimetric means for determining the reaction temperature of the desired components in a liquid medium. It may, on the other hand, comprise a spectroscopic device, advantageously a nuclear-resonance spectroscope adapted to determine the Lamor frequency of atoms introduced into a magnetic field.

The apparatus 9–12 may operate either continuously or intermittently during the blast, depending on whether it is desired to measure the temperature throughout the blowing operation or only at discrete intervals.

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7. Control desk

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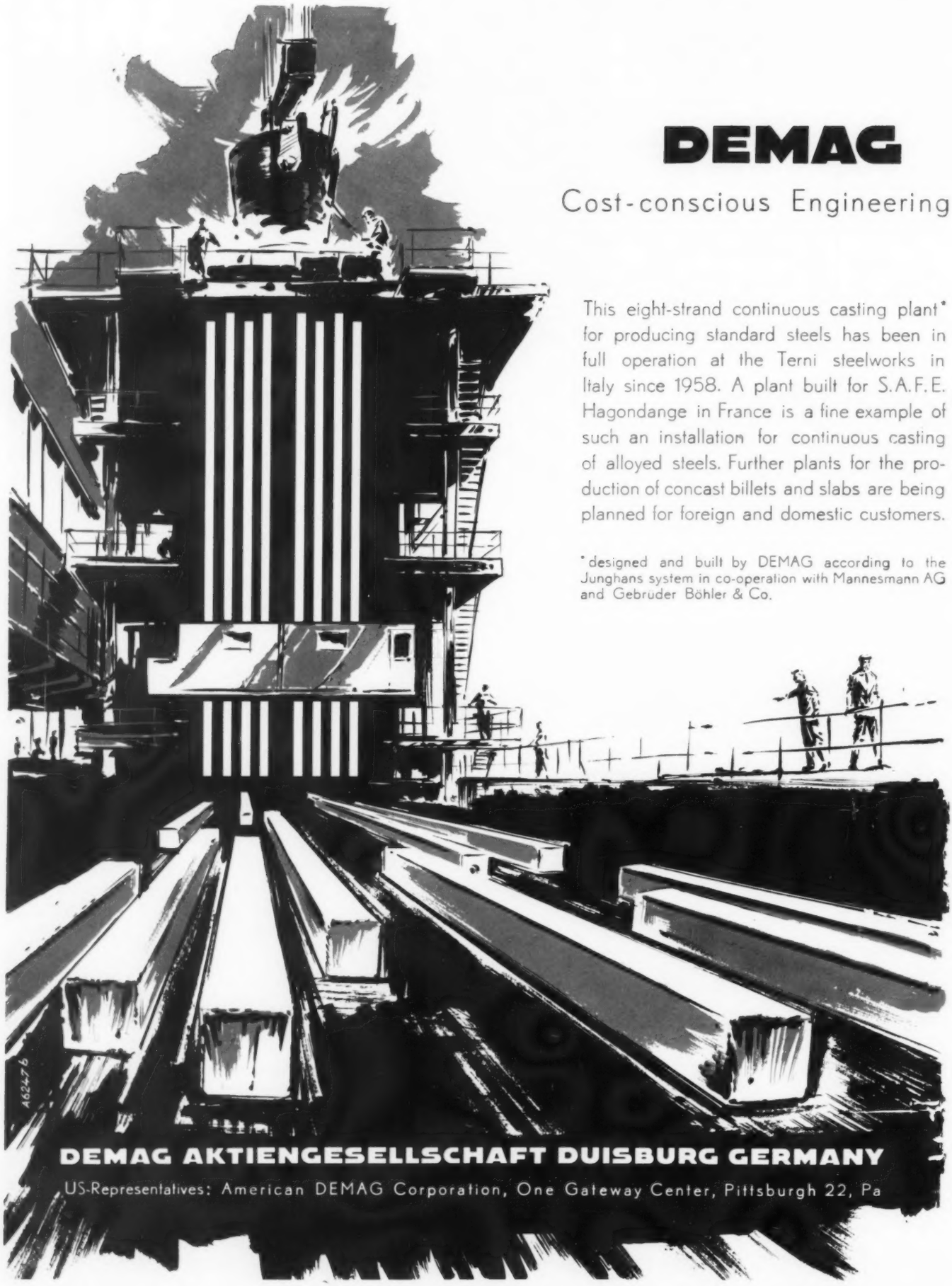

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*designed and built by DEMAG according to the Junghans system in co-operation with Mannesmann AG and Gebrüder Böhler & Co.

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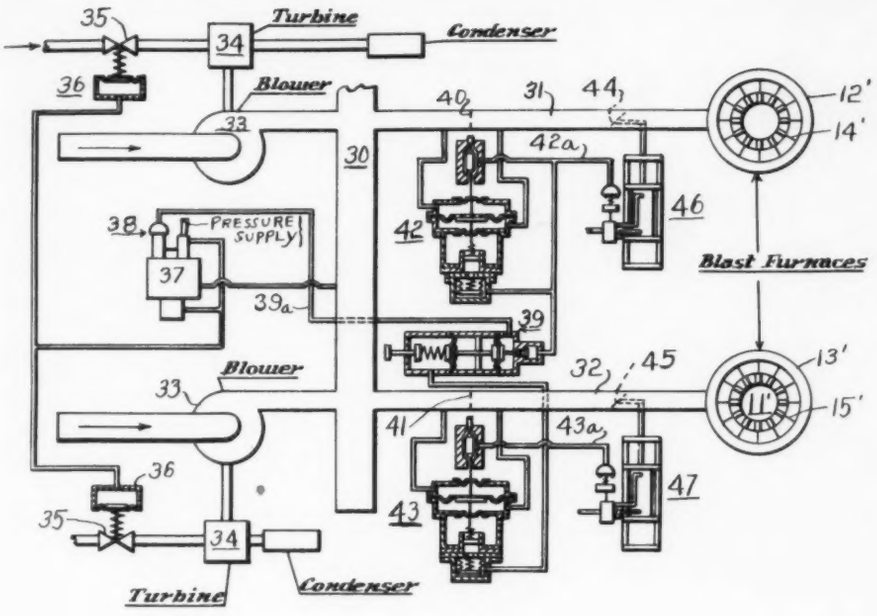

Figure 6

DISTRIBUTING WIND FROM TURBINE-DRIVEN BLOWERS TO THE BUSTLE PIPES OF BLAST FURNACES

△U. S. 2,942,866, issued June 28, 1960, to George R. Anderson and assigned to Hagan Chemicals & Controls, Inc., provides a method and apparatus for supplying to the bustle pipes of a number of blast furnaces the amount of wind for most economic and efficient operation of the wind system.

Prior to this invention, it was the practice to supply each of several blast furnaces of a steel mill with wind by its own steam turbine driven blower. The volume of wind delivered to any one of those furnaces was controlled by the speed of the blower for that furnace. The various blower speeds required for any one blast furnace were obtained by adjusting the steam input to its turbine. The volume of wind delivered to any given furnace was regulated by a wind volume controller that so adjusted the turbine speed as to hold the volume constant at a preset but adjustable value. Where many blast furnaces were involved in a given installation, the above system of supplying wind to each blast furnace was uneconomical in that the blowers usually had much more capacity than was ever used. Furthermore, it was not economical to operate the turbines and the blowers driven thereby over a wide range of speeds.

In the present invention, as shown in Figure 6 a number of steam-driven blowers 33 are utilized to supply the wind or blast to a common header 30. The bustle pipe of each of the several blast furnaces is supplied with blast by a supply or header pipe from that common header 30. Each header pipe is provided with an orifice and a butterfly valve. In order to utilize efficiently the capacity of the blowers and at the same time so operating the blowers that the turbines operate at an economical steam consumption, the supply of wind through the several header pipes to the bustle pipes of the respective furnaces is so controlled that one of the bustle pipes will receive the required amount of wind at substantially a zero pressure differential across the butterfly valve in its header pipe. In that case the butterfly valve in that pipe will be in open position. The valves in the other header pipes are then so modulated as to maintain volumetrically controlled supplies to each of the other bustle pipes. The system is so arranged that a butterfly valve in one of the header pipes will be automatically selected for wide open position when the furnace supplied by that header pipe receives enough wind when its valve is wide open. By wide open is meant that position of the valve which has substantially no regulating or throttling effect on flow. In that situation, the pressure at the bustle pipe will be substantially equal to the pressure in the common header.

Also the system is so arranged that it will automatically select the particular butterfly that is to be actuated to a wide open position. If, while a given valve is in wide open position, there is a tendency towards deficiency in wind to any one of the furnaces, a regulator responsive to the header pressure will be so loaded as to increase the speeds of the turbines thereby increasing the header pressure so that all of the bustle pipes of the blast furnaces will receive the required amount of wind.

IMMERSION TIN PLATING

△U. S. 2,940,867, issued June 14, 1960, to Michael A. Streicher and assigned to E. I. du Pont de Nemours & Co., describes a process for depositing tin on a selected area of a steel sheet.

The area to be coated is first mechanically roughened. Then there is applied to it an aqueous bath containing 10 to 40 grams per liter of stannous sulphate, 100 to 250 grams per liter of sodium bisulphate, and 30 to 100 grams per liter of unsubstituted polyethylene oxide having a molecular weight of about 6000.

PICKLING BATH

△ U. S. 2,941,949, issued June 21, 1960, to Albert J. Saukaitis and assigned to Amchem Products, Inc., provides a mineral acid bath for cleaning and pickling metal surfaces.

The bath contains, as an inhibiting agent to reduce the rate of acid attack on the metal, an amount of triphenyl sulfonium chloride.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,939,782	6/7/60	Refining of sponge iron	Julius D. Madaras
2,939,826	6/7/60	Electrolytic cleaning of ferrous metal objects	Graham L. Gulick
2,940,743	6/14/60	Heat treating furnace	National Furnace Corp.
2,940,879-80	6/14/60	Production of austenitic steel alloys	Standard Oil Co. (Ind.)
2,941,881	6/21/60	Drying and sintering ores	Metallgesellschaft A.G.
2,942,999	6/28/60	Laboratory test for determining brazeability of copper-plated steel strip	Pittsburgh Steel Co.

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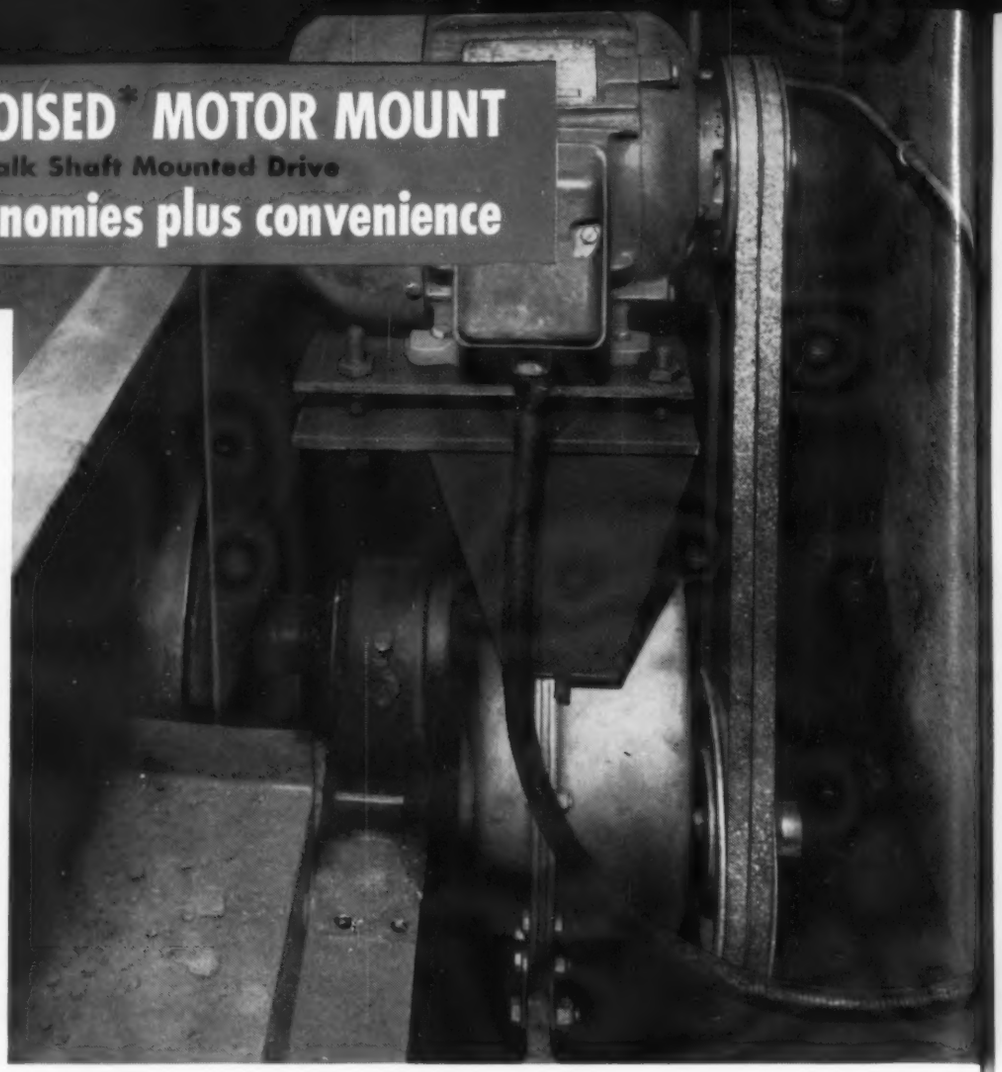
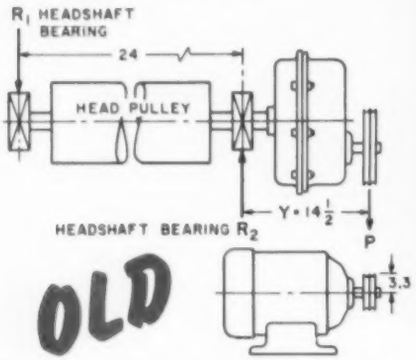


HOW A FALK EQUI-POISED MOTOR MOUNT REDUCES BEARING LOADS ON A DRIVEN MACHINE

GIVEN: Motor—15 hp, 1750 rpm, Frame 284U, Weight—320 lb.
Sheave diameters—6.6/9.4
Driven machine—belt conveyor with 24" center distance between headshaft bearings.

NOTE: Weights of 307J24 Shaft Mounted Drive, sheaves, and V-belts are eliminated from calculations because they remain constant; do not affect the comparison.

WITHOUT FALK MOTOR MOUNT



Torque at motor shaft = $\frac{63{,}025 \times 15 \text{ hp}}{1750 \text{ rpm}}$ = 540 lb-in.

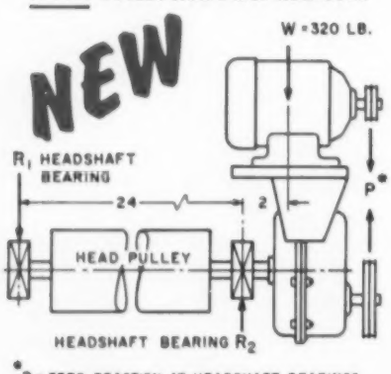
Belt pull (P) = $\frac{540 \text{ lb-in.}}{3.3"}$ x 1.5 Load Connection Factor
= 246 lb

$R_2 = \frac{246 \text{ lb} \times (24" + 14.5")}{24"}$ = 395 lb

$R_1 = \frac{246 \text{ lb} \times 14.5"}{24"}$ = 149 lb

(Check: 395 lb—149 lb=246 lb)

WITH FALK MOTOR MOUNT



*P = ZERO REACTION AT HEADSHAFT BEARINGS

V-belt pull has zero reaction on headshaft bearings. Therefore—

$R_2 = \frac{320 \text{ lb} \times (24" + 2")}{24"}$ = 347 lb

$R_1 = \frac{320 \text{ lb} \times 2"}{24"}$ = 27 lb

(Check: 347 lb—27 lb=320 lb)

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(*Balancing of forces.)

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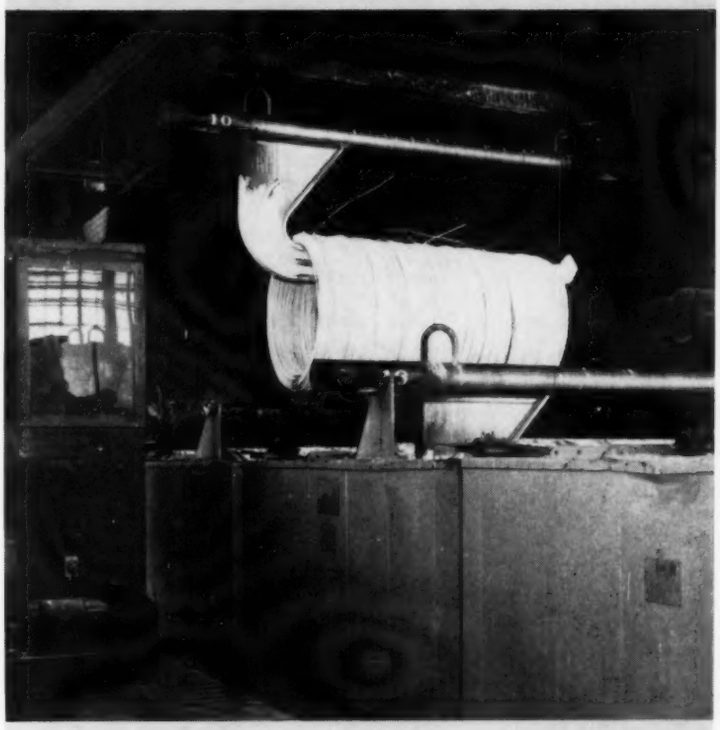

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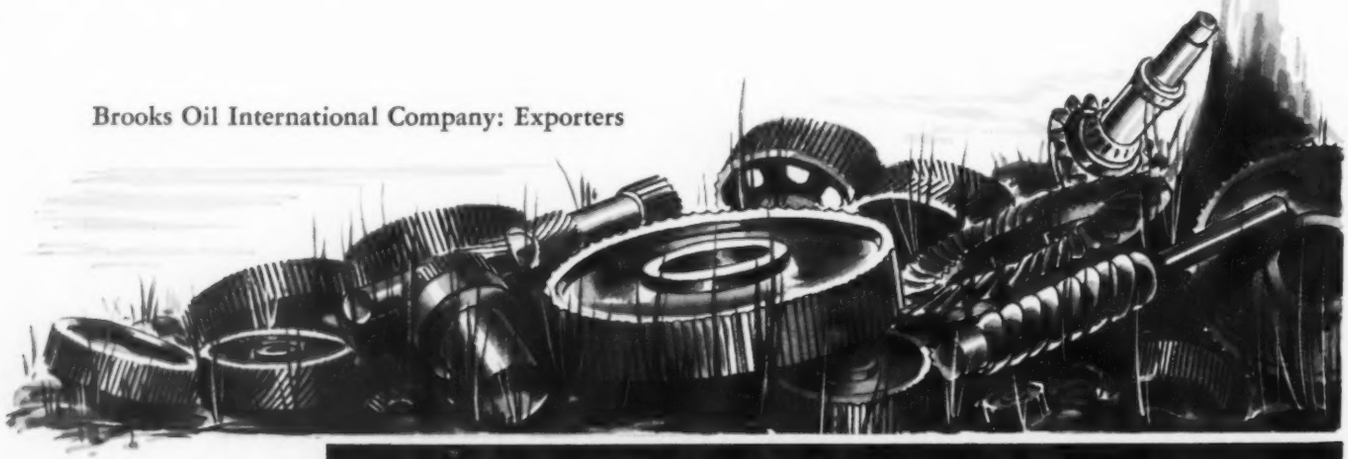

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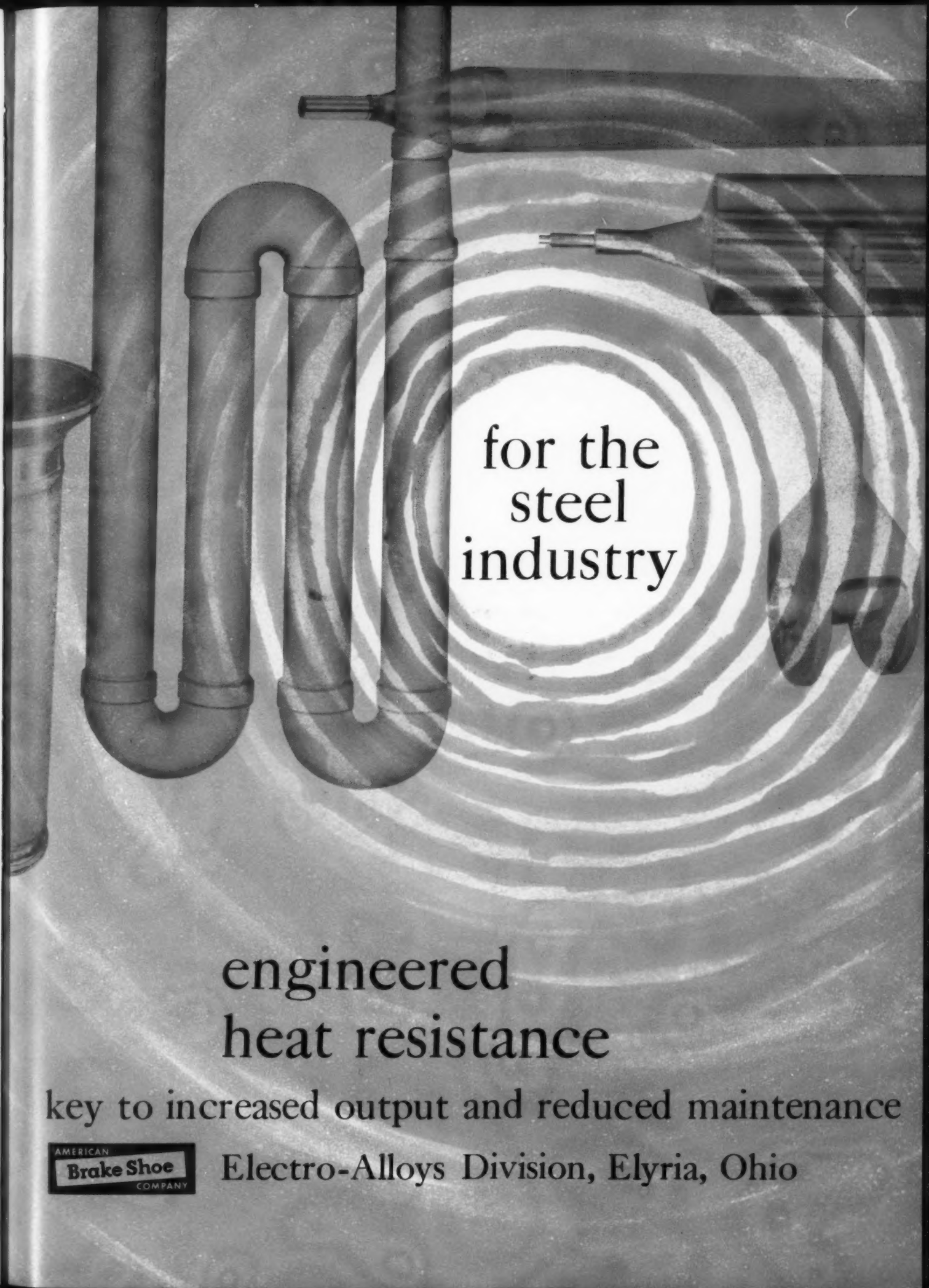
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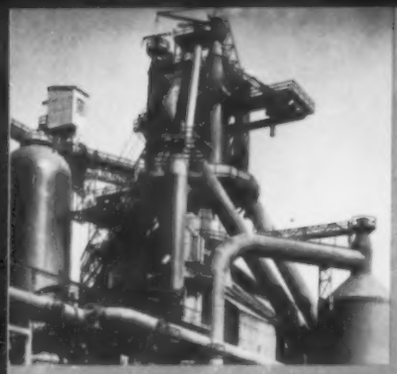
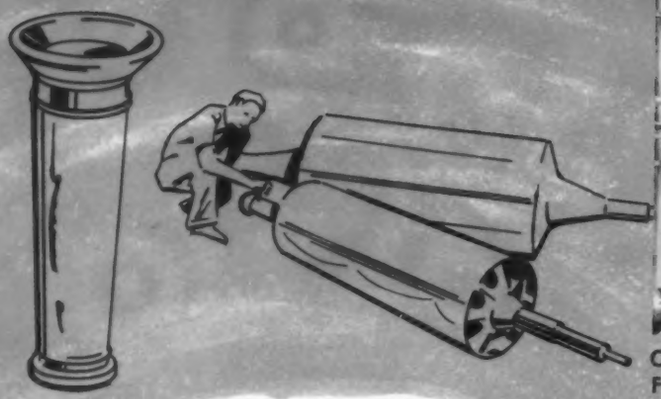
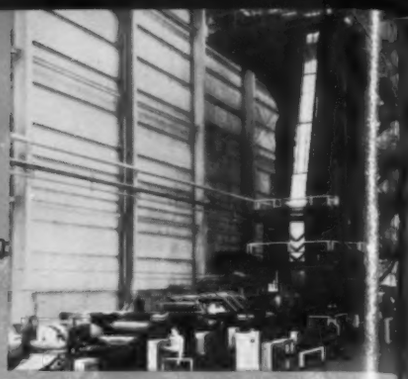


Blast Furnace Blowpipes





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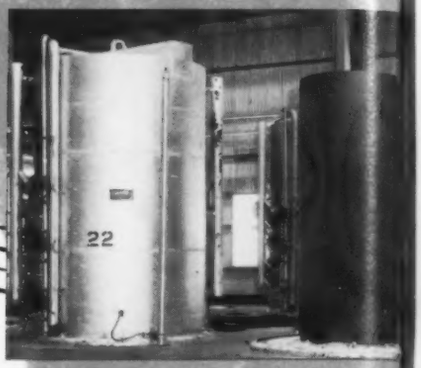
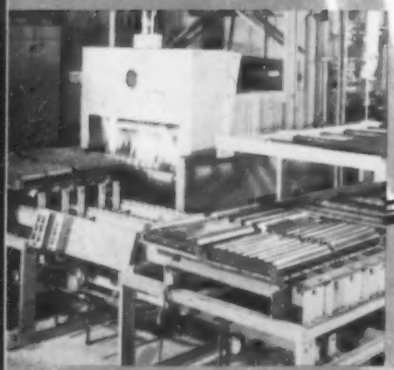
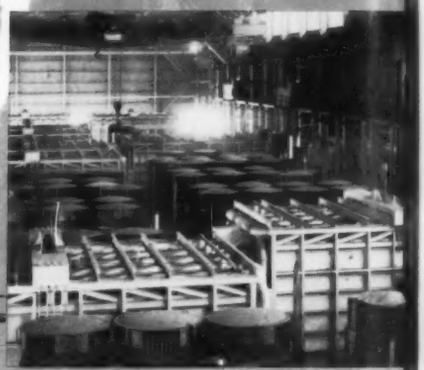


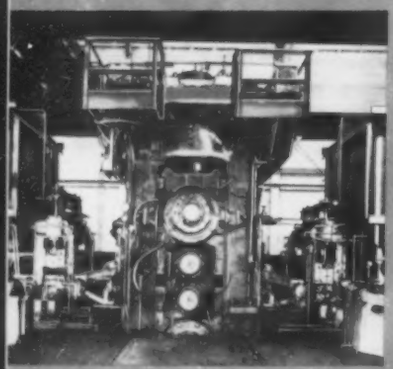
Single-Stack Annealing Furnace Radiant Tubes



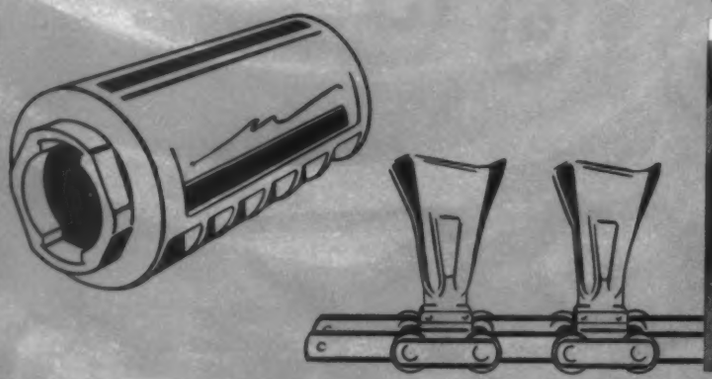
Roller Hearth Furnace Rolls

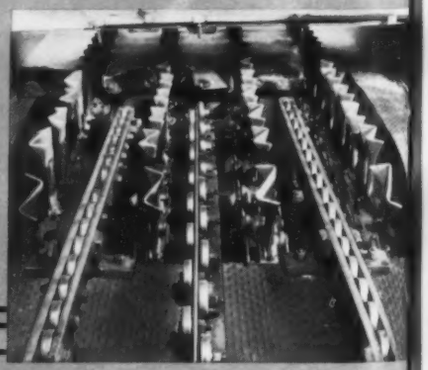


Multiple-Stack Annealing Furnace Radiant Tubes



One-Stand Four-High Reversing Mill Coiler Drums





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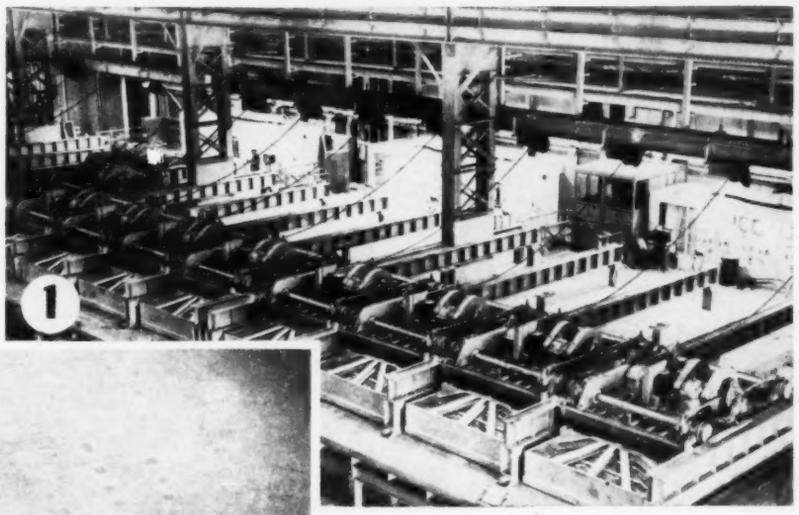

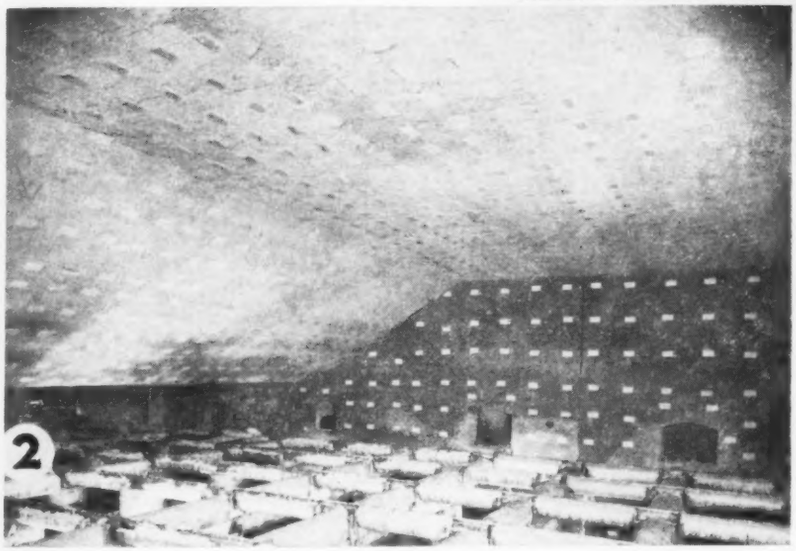

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1813 South Rockwell St., Chicago 8, Illinois

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 S. Rockwell St., Chicago 8, Ill.

☐ We are interested in Ramtite. Please furnish information.
☐ Send folder about your new Ramtite Product—"90-RAM."

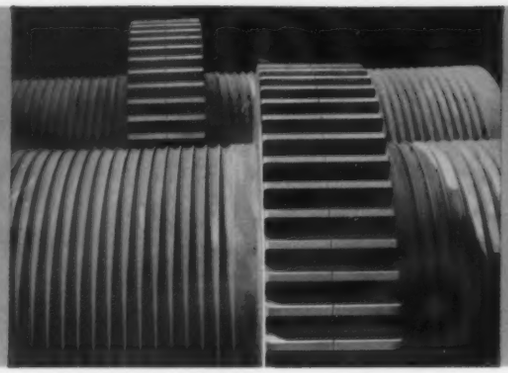
Company Name_____

Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

TSP sheaves on lower block of 7½ ton ore bucket. Note smooth throats after year's operation—Ore Yard.



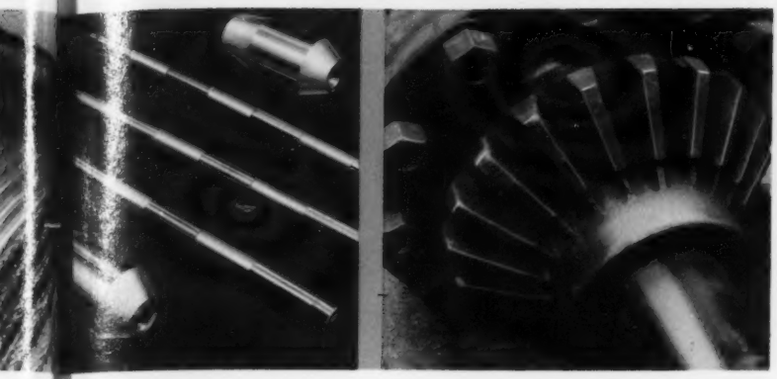
TSP large ring gears installed on spare rope drum for main hoist, 185 ton ladle crane—Open Hearth Dept.

TSP rope drum sleeve on chipping crane looks like new after 20 months service—Seamless Tube Dept.

TSP tubi... used on ...—Sear...

TSP on the job at JONES &

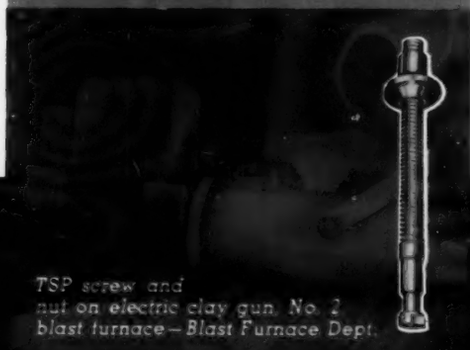
TSP pinion, ratchet wheel and pawls, of the type used successfully for several years. TSP gearing is used extensively on hot metal cranes—Open Hearth Dept.



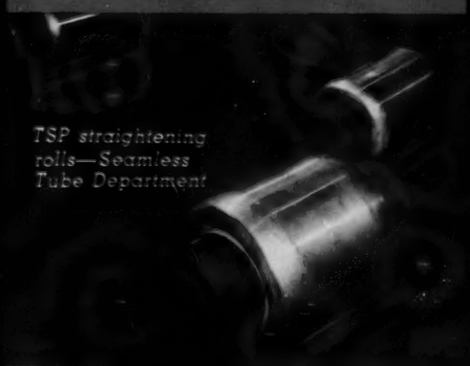
TSP tubing and pipe drifts, used on Hydrostatic tester —Seamless Tube Dept.

TSP flanged Randupson bevel installed on line shaft for No. 1 approach table—Blooming Mill.

TSP trolley wheel on charging machine—Open Hearth Department.

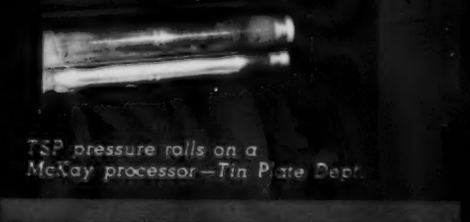


TSP screw and nut on electric clay gun, No. 2 blast furnace—Blast Furnace Dept.



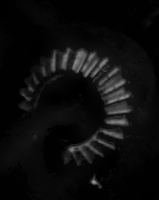
TSP straightening rolls—Seamless Tube Department

S & LAUGHLIN aliquippa works



TSP pressure rolls on a McKay processor—Tin Plate Dept.

THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO



TSP Randupson cast tooth bevels installed on line shaft for 30" round mill tables—Seamless Tube Department

AAF air filters *keep it that way* for Detroit Steel's Portsmouth Division

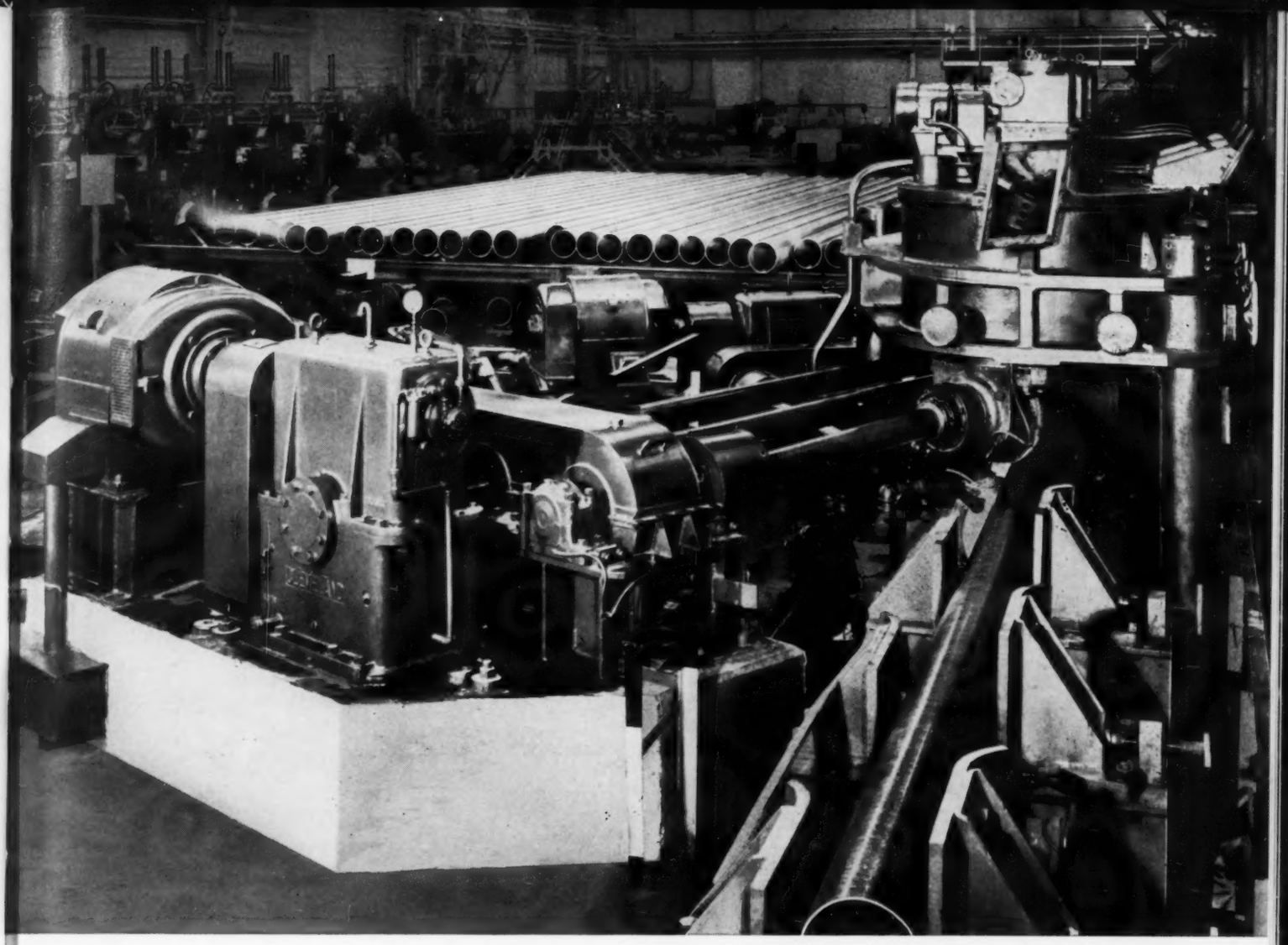
Did you ever see a cleaner, brighter motor room? It typifies the investment-protection planning that went into Detroit Steel's Portsmouth Division at Portsmouth, Ohio. From AAF's complete air filter line, the company was able to select the *right* filters to guarantee a continuing supply of clean air for long, uninterrupted motor room service.

Three distinctly different filter types are in operation — dry type, viscous impingement and electrostatic. They are supplying nearly 300,000 cfm of super-clean air to motor rooms serving blooming mill and cold mill operations.

The filters — Roll-O-Matic, Multi-Duty and Electro-Matic — are all automatic, self-cleaning units. For complete information on any or all, call your local American Air Filter representative or write us direct. Address: Mr. Robert Moore, American Air Filter Company, Inc., 302 Central Avenue, Louisville, Kentucky.

AAF American Air Filter

BETTER AIR IS OUR BUSINESS



How to straighten the really big pipe!

One major Eastern steel producer has found the answer – the big Mack-Hemp Model A-5 Straightener shown above—the largest of its type in the world!

This A-5 takes really big bowed pipe from the sizing mill, pulls it in through three pairs of opposed cross rolls and then spins it out straight and round to high tolerances in only a single pass.

This despite the fact that the steel pipe being straightened is 16-inch in diameter, fifty feet in length!

To do a job like this, of course, the massive 85-ton roll frame is a must, as are the heavy duty rolls, and the combined 200 HP motors used to drive all six of them. In its first year, this Mack-Hemp A-5 straightener has handled more than 200,000 tons of pipe.

If straightening pipe or tubing is your problem – any size, any alloy – consider doing it yourself. The men from Mack-Hemp will be glad to give you all the facts you'll want to know.

MACKINTOSH-HEMPHILL
Division of E. W. BLISS Company
Pittsburgh and Midland, Pa.

MACKINTOSH-HEMPHILL DIVISION · PITTSBURGH · U.S.A. ·

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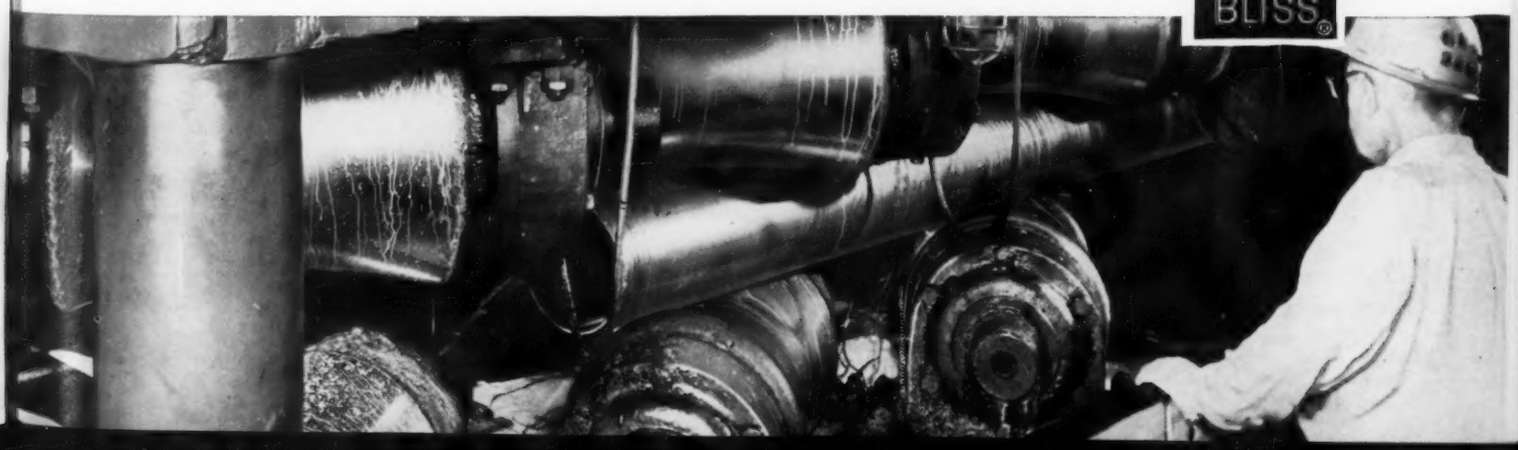

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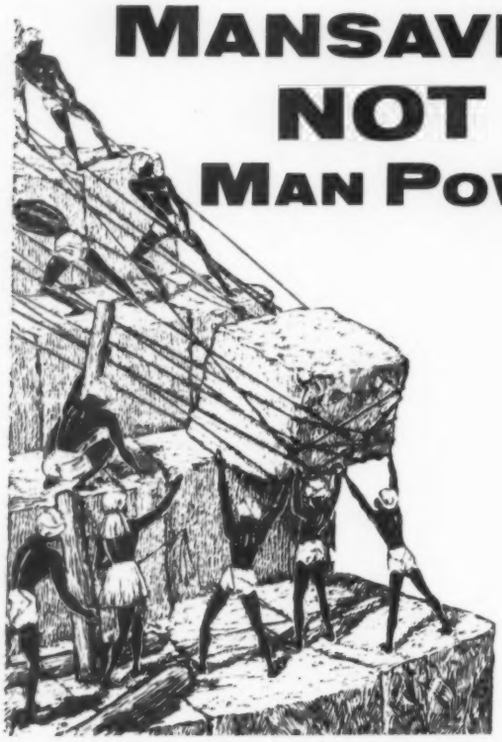
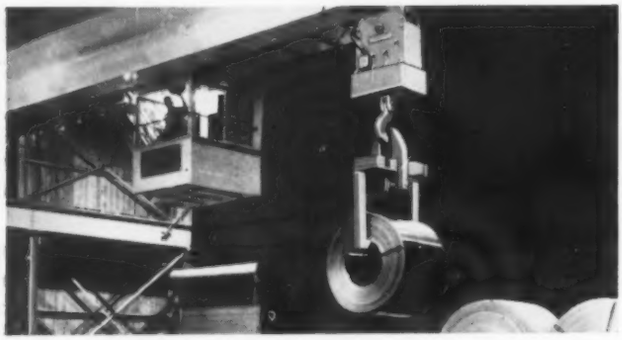


MANSAVER® GRABS SAVE LABOR and SPACE



The Mansaver Style 1418 motor-driven coil grab, because of its telescoping construction can stack coils evenly, close together and higher, increasing floor space and providing more manufacturing area. In this installation it is suspended from a Mansaver 1588 motorized crane hook with collector rings for carrying current to the grab. Full 360 degree rotation is provided. When volume handled is small, savings can be made by using a similar grab for hand operation.

Whether *your* plant handles metal sheets, coils, palletized or skid-loads, bars, billets, rods, tubes, boxes, barrels or other materials, Mansaver can supply a manual, semi-automatic, fully-automatic, or power-operated Grab for your handling requirements.

Ask our District Representatives into your plant to study your handling problem for presentation for our solution.

MANSAVER INDUSTRIES, Inc.

3116 East St.,
New Haven, Conn.

Also Manufactured in England by George W. King Co. and in France by Ets. Dujardin et Cie.

GRID's got to be good!

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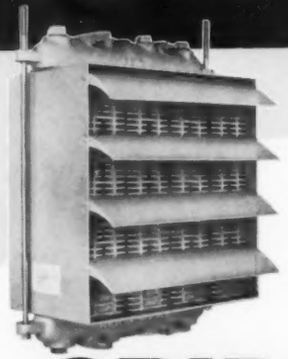

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GRID ▶ UNIT HEATERS
BLAST HEATERS
RADIATORS

for a trouble-free, low maintenance cost heating system - One that will serve without service - Installations made in 1929 are still operating without need for repairs. GRID'S design and construction makes the difference!

GRID Cast Iron Construction resists corrosion externally from acid fumes and internally from electrolysis. No leaking from rotted cores.

GRID one-piece cast iron heating sections and headers are leak-proof on steam pressure up to 250 p.s.i. 450° temperature. Smaller steam lines cost less.

GRID heating sections with widely spaced fins cast integral with steam chambers are easy to clean - Will not "mat" on air intake side.

GRID design develops low outlet temperatures and, with proper fan volumes, delivers warm, comfortable air to floor - No wasted heat at ceiling.

Get complete information on a GRID System for your plant. Write for catalog #956 GRID CAST IRON STEAM HEAT TRANSFER SURFACE.

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AMERICAN CHAIN & CABLE SWIFT & CO. WHEELING STEEL CORPORATION
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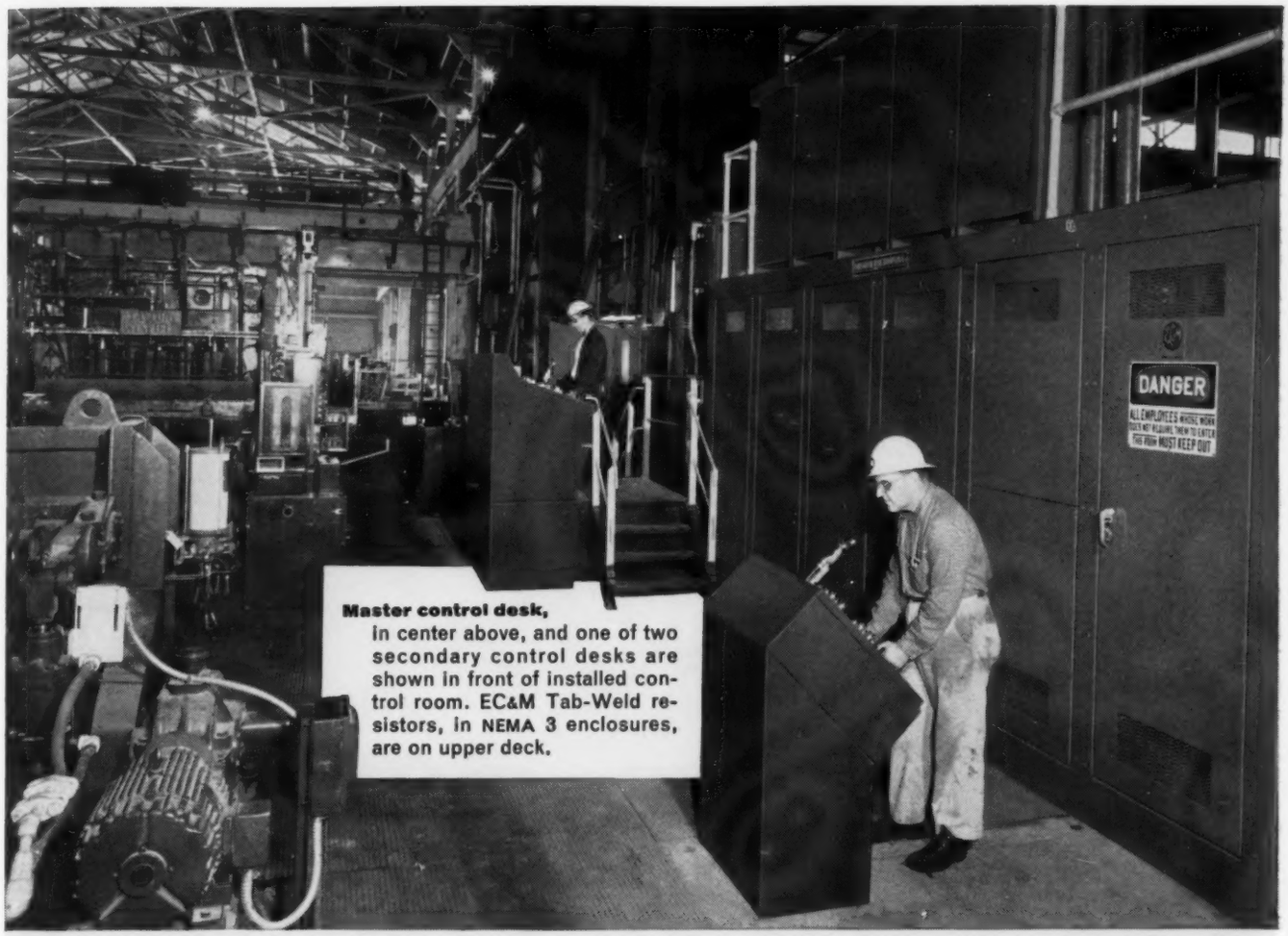
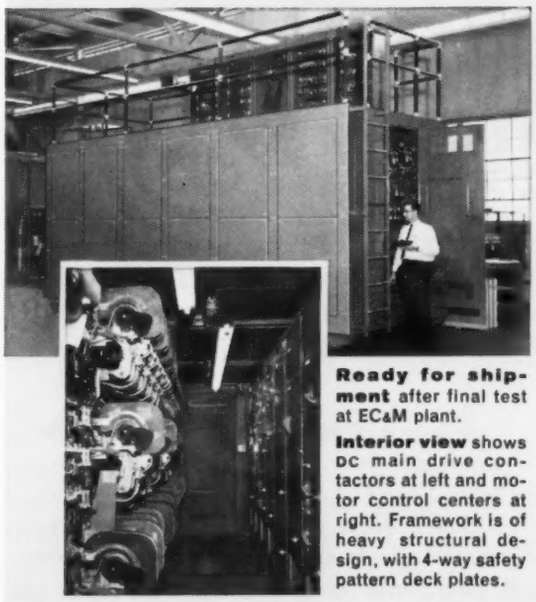


Master control desk, in center above, and one of two secondary control desks are shown in front of installed control room. EC&M Tab-Weld resistors, in NEMA 3 enclosures, are on upper deck.

14-ton Mill-Line Control Room cuts installation time IN HALF!..



Ready for shipment after final test at EC&M plant.

Interior view shows DC main drive contactors at left and motor control centers at right. Framework is of heavy structural design, with 4-way safety pattern deck plates.

• This giant control room, built by EC&M for a coil welding line in a major steel mill, was installed and ready for operation in half the time usually required. Completely pre-wired and interconnected, the packaged unit eliminated the four to five weeks of installation time normally required for wiring and testing. At the mill site, the control room was placed over an open pit which already contained power cables and control wiring.

The control room measures 8 feet wide, 21 feet long and 14 feet high. It contains all the control panels for operating the DC main drives, AC auxiliary drives, and for supplying low voltage DC power for jogging and threading.

For any mill drive, EC&M can design and build a control room which will save space, drastically cut installation time and trouble, and get your drive in operation faster.

Write for details • **Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio**

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wherever electricity is distributed and controlled.

5484

MOVIE: "STOP LOSS WITH ORGANIZED LUBRICATION," a new 20-minute color-and-sound film created to show the opportunities for cost control through Organized Lubrication.

EDUCATIONAL FILM PACKAGE for plant departments consists of movies on greases, hydraulic oils, cutting oils, etc., that may be selected after seeing the "Stop Loss" film.

HERE ARE THE TOOLS THAT CAN HELP YOU

INCREASE YOUR NET PROFITS

Texaco's new "Stop Loss" program is designed to cut maintenance costs by modernizing lubrication practices. If yours is an average plant, the results can add 4 per cent to your net profit.

Even if your plant is an efficient operation, it is still virtually certain that there is an opportunity for cost control you are overlooking—either partially or completely. Here's what the Small Business Administration says in a recent publication:

Suppose there is an average plant, which sells $1,000,000 worth of goods per year. The net profit of this average company would be $73,400 and the maintenance cost would be $29,900. Now, suppose that by *better lubrication*, maintenance costs are reduced 10%, or $2990, *the $2990 will go directly into profit*—an increase of 4%.

A Texaco "Stop Loss" Program is designed for you. Texaco has developed a program specifically designed to help cut your maintenance costs via better lubrication practices. It will help you increase machine life, minimize downtime, reduce lube inventory, even cut purchasing costs. And the savings you make go directly into profits.

CO-ORDINATED BOOKLETS on the film subjects and others can be used as guides in specific areas.

TEXACO LUBRICATION CONTROL SYSTEM takes the guesswork out of your lubrication scheduling. It costs almost nothing to install, yet can add thousands of dollars a year to profits.

BY AS MUCH AS 4 PER CENT!

Can your plant pass this test? If the answer is "no" to any of the following questions, it is almost certain that a Texaco "Stop Loss" Program can improve your profit picture.

1. Is there a central source of responsibility in your plant for *all* lubrication? Yes ☐ No ☐
2. Can your machine operators devote all their time to production without worrying about lubrication? Yes ☐ No ☐
3. Is there any system for making sure that equipment gets lubricated in the right spots at the right time? Yes ☐ No ☐
4. Have you had a lubrication study made to eliminate costly duplication of lubricants? Yes ☐ No ☐
5. Are your oilers qualified men with knowledge of mechanisms lubricated? Yes ☐ No ☐

See for yourself how "Stop Loss" works! Texaco has just released a new color-and-sound movie to dramatize the benefits of good lubrication practices. It's called "Stop Loss through Organized Lubrication" and we think it would be valuable to you to see it. For a showing in your plant soon, mail in the coupon today!

Texaco Inc., 135 East 42nd Street, New York 17, N. Y.

MAKE YOUR RESERVATION TODAY!

TEXACO INC., Dept. IS-161
135 East 42nd Street
New York 17, New York

I would like to see "Stop Loss through Organized Lubrication." Please call to arrange a showing in my plant.

Name_____ Title_____

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TEXACO

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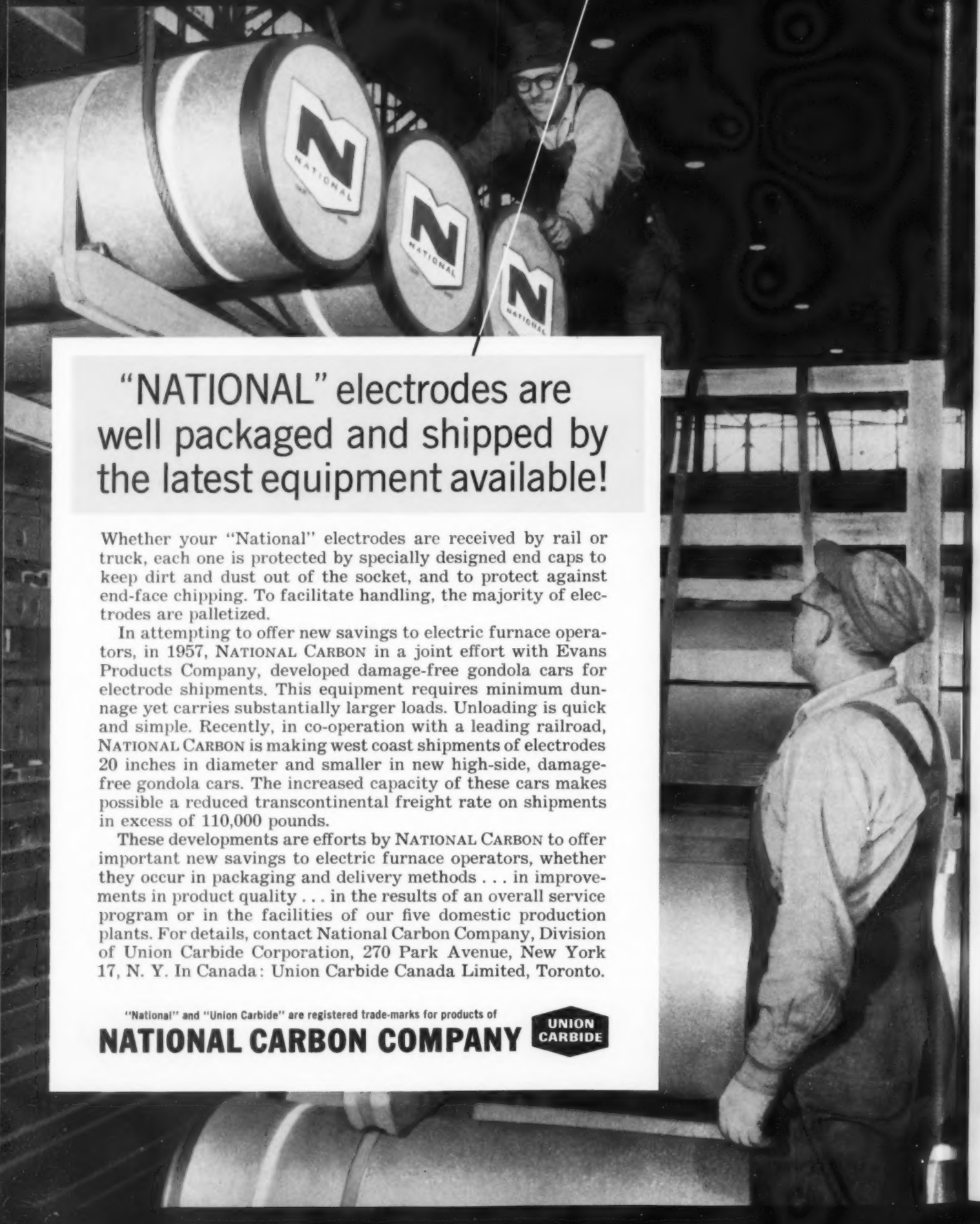
QUALITY • SERVICE DELIVERY FACILITIES!



"NATIONAL" electrodes are well packaged and shipped by the latest equipment available!

Whether your "National" electrodes are received by rail or truck, each one is protected by specially designed end caps to keep dirt and dust out of the socket, and to protect against end-face chipping. To facilitate handling, the majority of electrodes are palletized.

In attempting to offer new savings to electric furnace operators, in 1957, NATIONAL CARBON in a joint effort with Evans Products Company, developed damage-free gondola cars for electrode shipments. This equipment requires minimum dunnage yet carries substantially larger loads. Unloading is quick and simple. Recently, in co-operation with a leading railroad, NATIONAL CARBON is making west coast shipments of electrodes 20 inches in diameter and smaller in new high-side, damage-free gondola cars. The increased capacity of these cars makes possible a reduced transcontinental freight rate on shipments in excess of 110,000 pounds.

These developments are efforts by NATIONAL CARBON to offer important new savings to electric furnace operators, whether they occur in packaging and delivery methods . . . in improvements in product quality . . . in the results of an overall service program or in the facilities of our five domestic production plants. For details, contact National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

"National" and "Union Carbide" are registered trade-marks for products of

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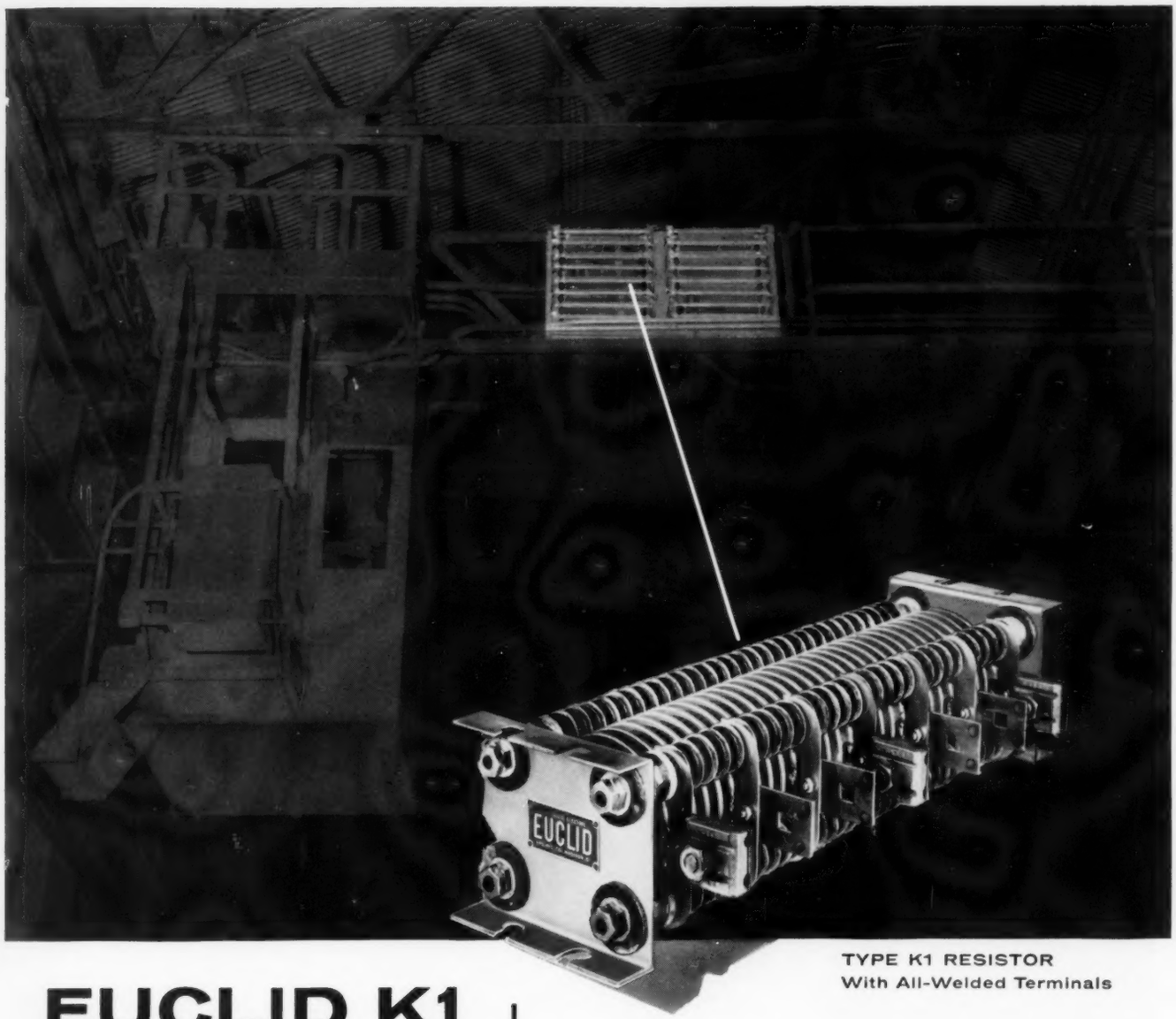

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Installation on Steel Mill Crane

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WHAT'S YOUR PROBLEM?

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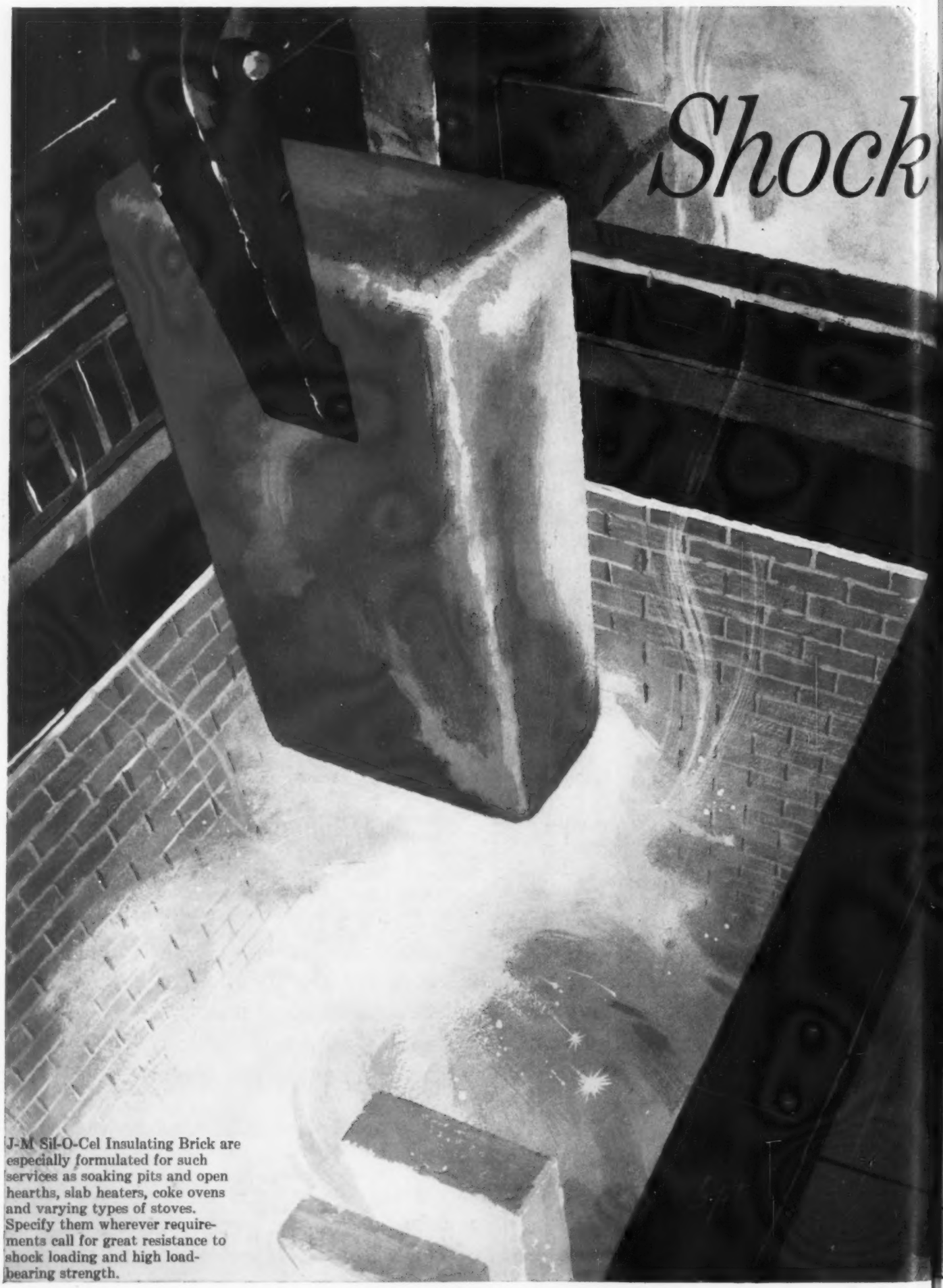

J-M Sil-O-Cel Insulating Brick are especially formulated for such services as soaking pits and open hearths, slab heaters, coke ovens and varying types of stoves. Specify them wherever requirements call for great resistance to shock loading and high load-bearing strength.

loads...and crushing weight

call for Johns-Manville Sil-O-Cel Insulating Brick!

Hot blast stove walls, open hearths, soaking pit bottoms—the unexcelled performance of J-M Sil-O-Cel® brick in rugged services like these explains their wide acceptance. Today, they are used as back-up insulation by virtually every major equipment builder.

Made of heat-resistant diatomaceous silica, Sil-O-Cel Insulating Brick are produced in three load-bearing types: Sil-O-Cel *Super* (to 2500F) and Sil-O-Cel *C-22* (to 2000F) for peak performance and long life under extremes of heat, weight and shock. Sil-O-Cel *16L* combines performance and economy for lower temperatures to 1600F.

To bring you the right brick for your needs, Johns-Manville *also* offers six Insulating Fire Brick types. This wide selection of Insulating Fire Brick lets you choose the *one* brick that gives you the most favorable combination of temperature resistance, strength, conductivity, density and cost.

Write today for your copy of IN-115A, 8-page booklet on Johns-Manville Insulating Fire Brick. It gives complete physical and thermal properties of each type, along with sizes and shapes available. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

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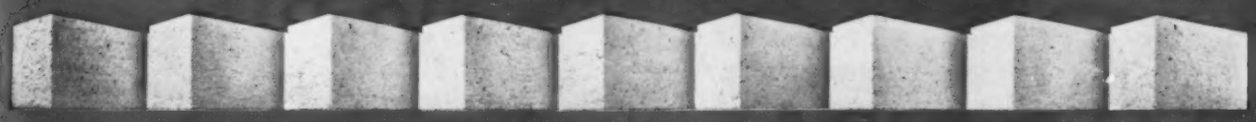
THE INDUSTRY'S MOST COMPLETE LINE OF INSULATING FIRE BRICK



JM-3000	JM-28	JM-26	JM-23	JM-20	JM-1620	Sil-O-Cel® Super	Sil-O-Cel C-22	Sil-O-Cel 16L
service to 3000F	service to 2800F	service to 2600F	service to 2300F	service to 2000F	to 1600F exposed; to 2000F back-up	to 2500F back-up	to 2000F back-up	to 1600F exposed or back-up

RW-300

the most field-reliable computer control system . . .

FOR AUTOMATIC CONTROL IN STEEL MILLS

Applied to the operation of a blast furnace, RW-300 digital computer control can result in a 2 to 4 percent increase in production rate or decrease in coke consumption. Measured over a year, such improvements in the return from *one* furnace can equal the investment in an RW-300 system. Similar cost reductions and production increases can be realized through computer control of sintering plants, open-hearth furnaces, oxygen converters, rolling mills, annealing and plating lines, and other processes in existing or new steel mills.

In an effort to boost profits by reducing costs and increasing throughput, many leading steelmakers are now considering computer control, and uppermost in their minds is the question of system reliability proven in the field. More than a dozen RW-300 systems are now operating around the clock in rugged industrial environments.

For further information, call or write Mr. Dan L. McGurk, Manager of Sales.

TRW Computers Company

a division of ***Thompson Ramo Wooldridge Inc.***

202 NORTH CANON DRIVE • BEVERLY HILLS, CALIFORNIA

DAILY GRIND ALWAYS UNIFORM
with Pennsylvania Reversible Hammermills

Regardless of condition of coal or amount of hammer wear—Pennsylvania Hammermills are noted for producing a highly uniform product day after day.

Basic design and simple adjustments available to the operator on the spot make this possible.

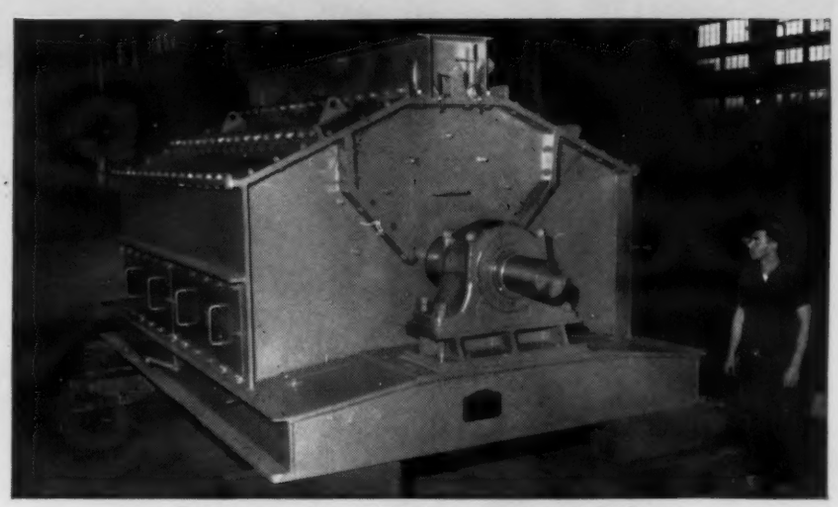
Pin point adjustments of cage-hammer clearance (by ratchet wrench and worm gear assembly) compensate for hammer wear or coal condition.

Crushing action keeps fines to minimum. Free air impact crushing in upper zone prepares coal so there is little dredging of hammers through oversize in cage-bar zone. Results—uniform grinds day after day.

DOUBLE CRUSHING AREA: DOUBLE CAGE, BLOCK AND HAMMER LIFE

No other crushers give you so much more for your money. Pennsylvania Reversible Hammermills give double the crushing area—double the life of cage bars, breaker blocks and hammers. A flick of the switch; rotor is reversed and you are using a duplicate mill.

What's more, hammers need never be hand turned, and wear is kept uniform.



• Pennsylvania Reversible Hammermill, typical of type used in by-product coke plants, ready for shipment.

With adjustable cage assemblies, hammers can be worn much further while keeping grind uniform—with no falling off of tonnage.

FREE BULLETIN

Bulletin 1040, giving a full description of the design, construction features, operation and maintenance of Pennsylvania Reversible Hammermills, can prove profitable reading for you. Write for a copy today.

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DOUBLE DIVIDEND!
Pennsylvania Bradford Breaker cleans coal as it crushes

Famous Pennsylvania Bradford Breakers not only crush and size run-of-mine coal—they automatically remove and discharge tramp iron and other refuse. This is just one of many features giving Pennsylvania world leadership for this type of crusher. Over 60 million tons of coal annually are prepared by Pennsylvania Bradfords in coke plants everywhere.

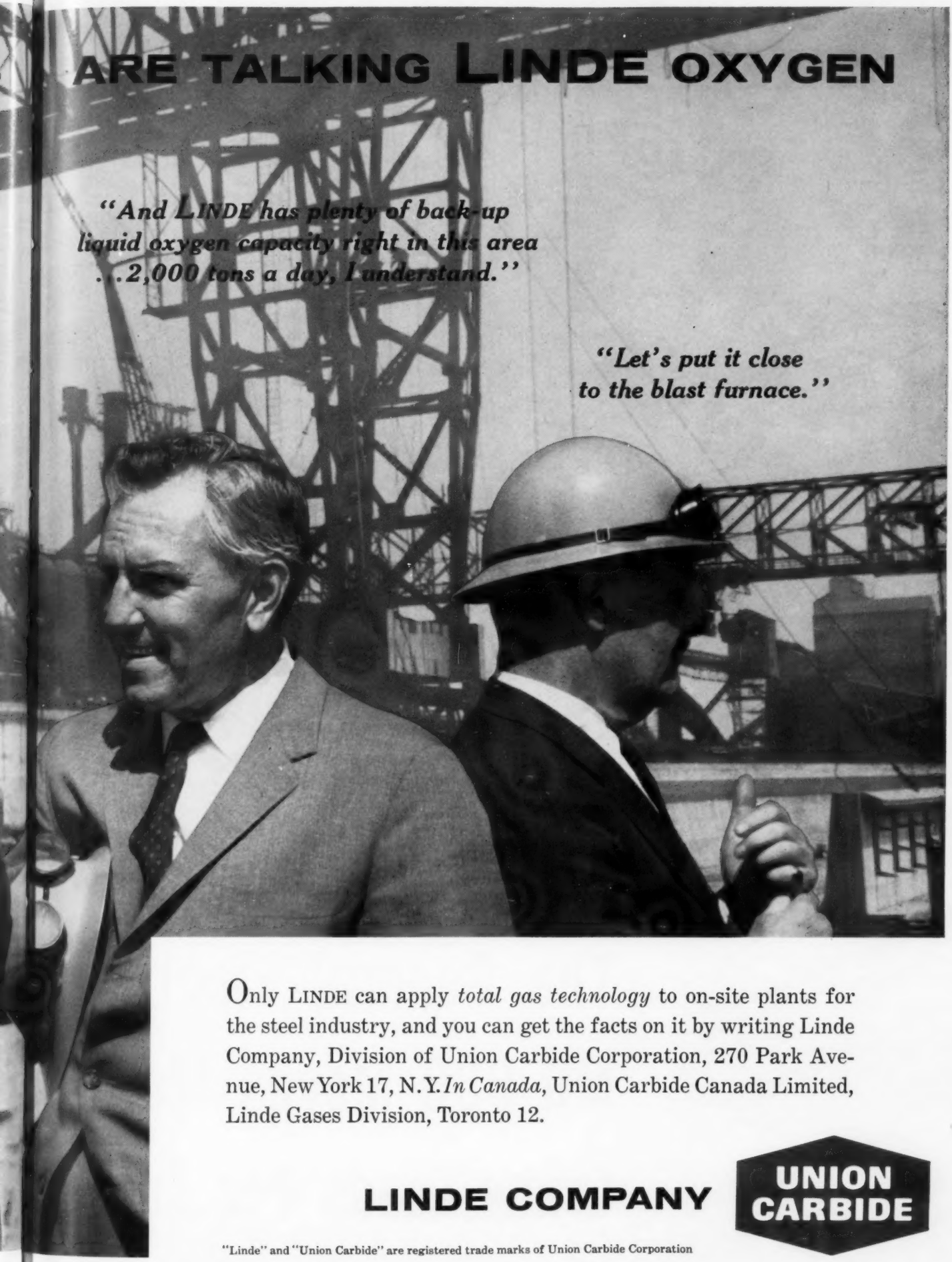
For complete information, write and ask for Bulletin 3009.

★ ★ ★

Over 50 years concentrated experience in all types of material reduction makes Pennsylvania your best source of crushers and engineering advice and service. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

PENNSYLVANIA
BATH-BUILT
CRUSHERS

MEN TALKING STEEL
"If we need that much oxygen, we need an on-site plant."
"LINDE will build us a plant and bear the whole cost. We wouldn't be risking any of our own capital."


ARE TALKING LINDE OXYGEN
"And LINDE has plenty of back-up liquid oxygen capacity right in this area ...2,000 tons a day, I understand."
"Let's put it close to the blast furnace."

Only LINDE can apply *total gas technology* to on-site plants for the steel industry, and you can get the facts on it by writing Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N.Y. *In Canada,* Union Carbide Canada Limited, Linde Gases Division, Toronto 12.

LINDE COMPANY UNION CARBIDE

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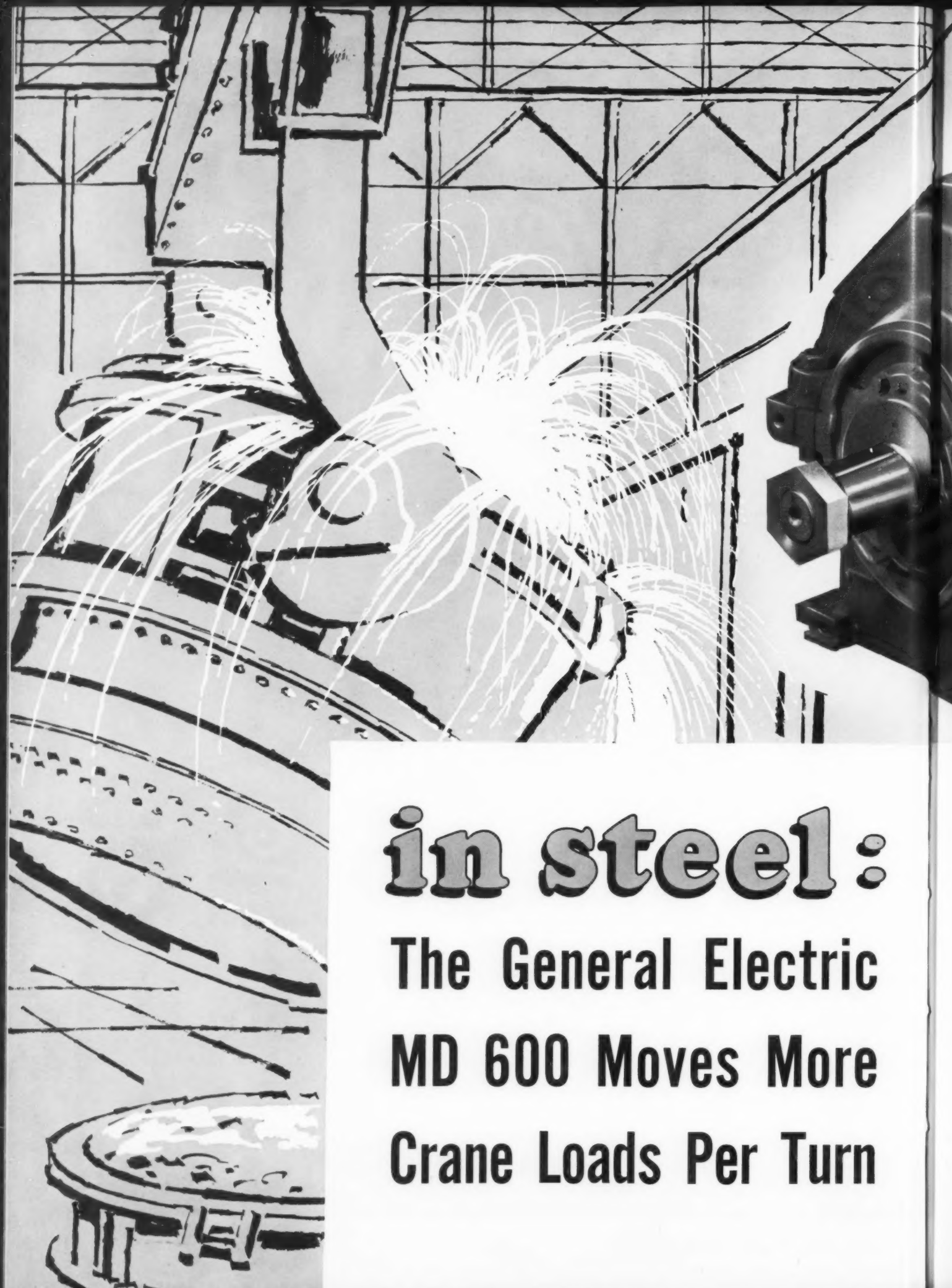
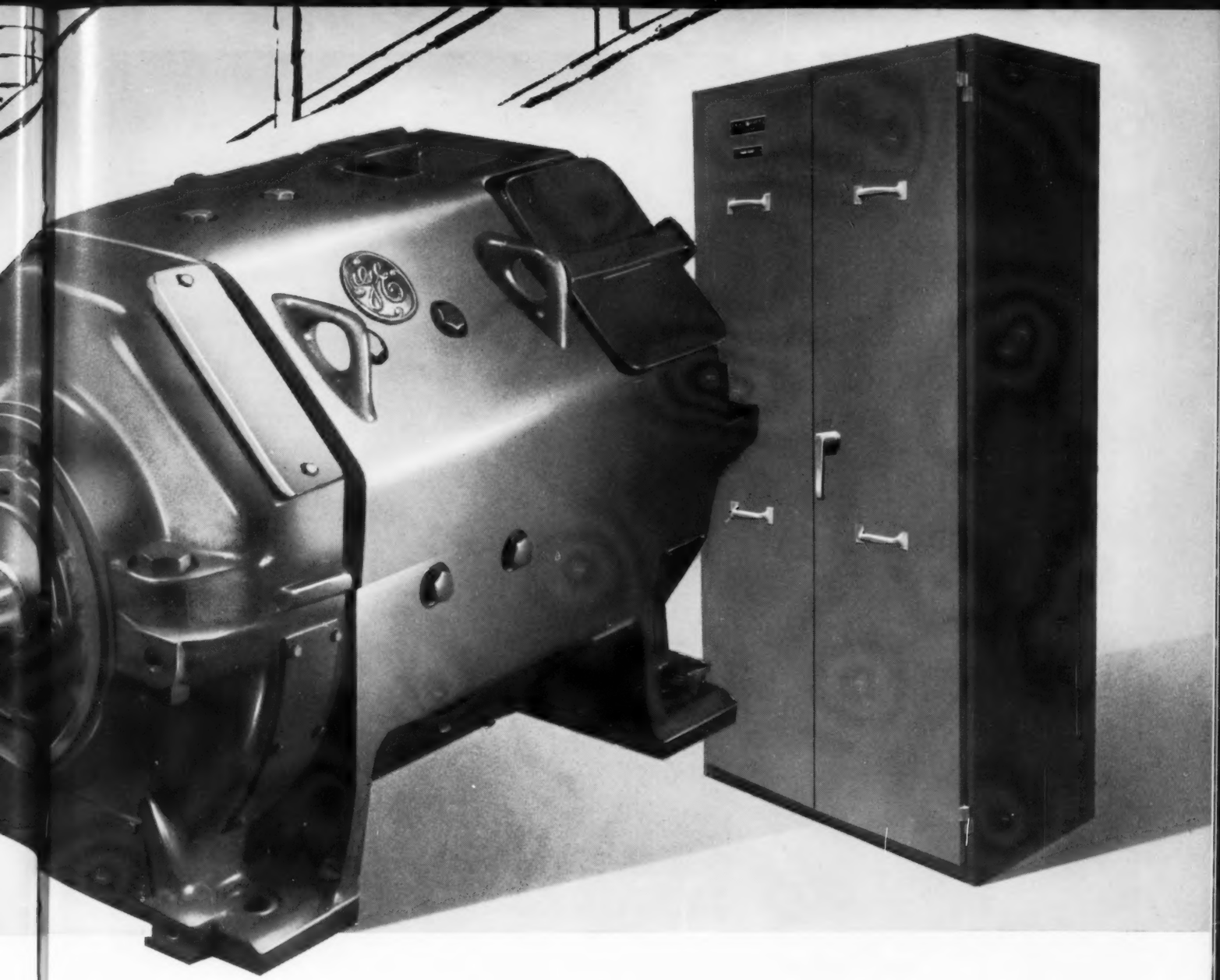


in steel:

The General Electric MD 600 Moves More Crane Loads Per Turn



Fast response, minimum down time, and unmatched maintenance ease—for more crane loads per turn—typify the performance you get from the versatile MD 600 DC Mill Auxiliary Motor.

General Electric's MD 600 armored motor is designed and engineered to give outstanding performance under the demanding duty cycles found in steel-mill crane-drive applications. These MD 600 motors have an outstanding performance record sustained through thirteen years of dependable service in steel-mill drive applications. And General Electric has designed a new compact control unit, offering advanced control characteristics in 50% less space to give you improved crane performance.

Put this profit making crane drive to work in your mill. For complete information on General Electric MD 600 motors and crane control, contact your nearest Apparatus Sales Office, or write to Section 827-05, General Electric Company, 1 River Road, Schenectady 5, New York.

Industry Control Dept., Salem, Virginia
Direct Current Motor and Generator Dept., Erie, Pa.

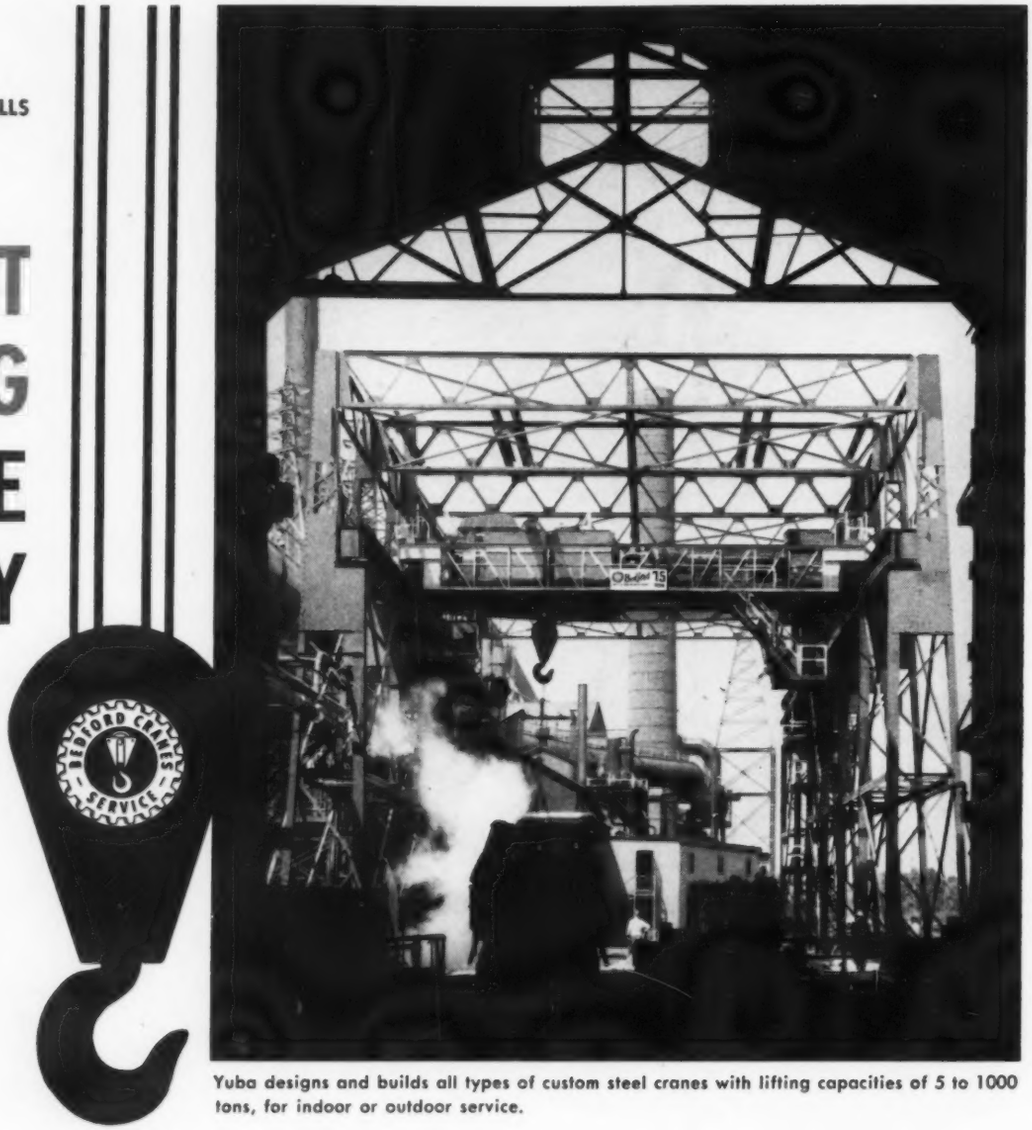
827-05

Progress Is Our Most Important Product

GENERAL ELECTRIC

IN STEEL MILLS

WEIGHT LIFTING MADE EASY



Yuba designs and builds all types of custom steel cranes with lifting capacities of 5 to 1000 tons, for indoor or outdoor service.

Yuba-Bedford Steel Mill Cranes are working to plant capacity —24 hours a day —year after year

Two generations of steel makers have operated Bedford Cranes in mills from Pennsylvania to Peru. These are mills where the handling jobs are tough—where cranes work shift after shift under all conditions —and where there's time for only routine maintenance.

Hundreds of Bedford Cranes have been manufactured for leading steel producers...cranes that are specially designed and custom-built by Yuba to the tough requirements of the steel industry. Big lifting problems are made easy on every shift—for years!

Yuba designs, builds and erects all types of cranes including bridge, unloading and material handling, gantry and semi-gantry, floating and jib cranes. Also derricks, hoists and launching towers for defense ordnance.

YUBA

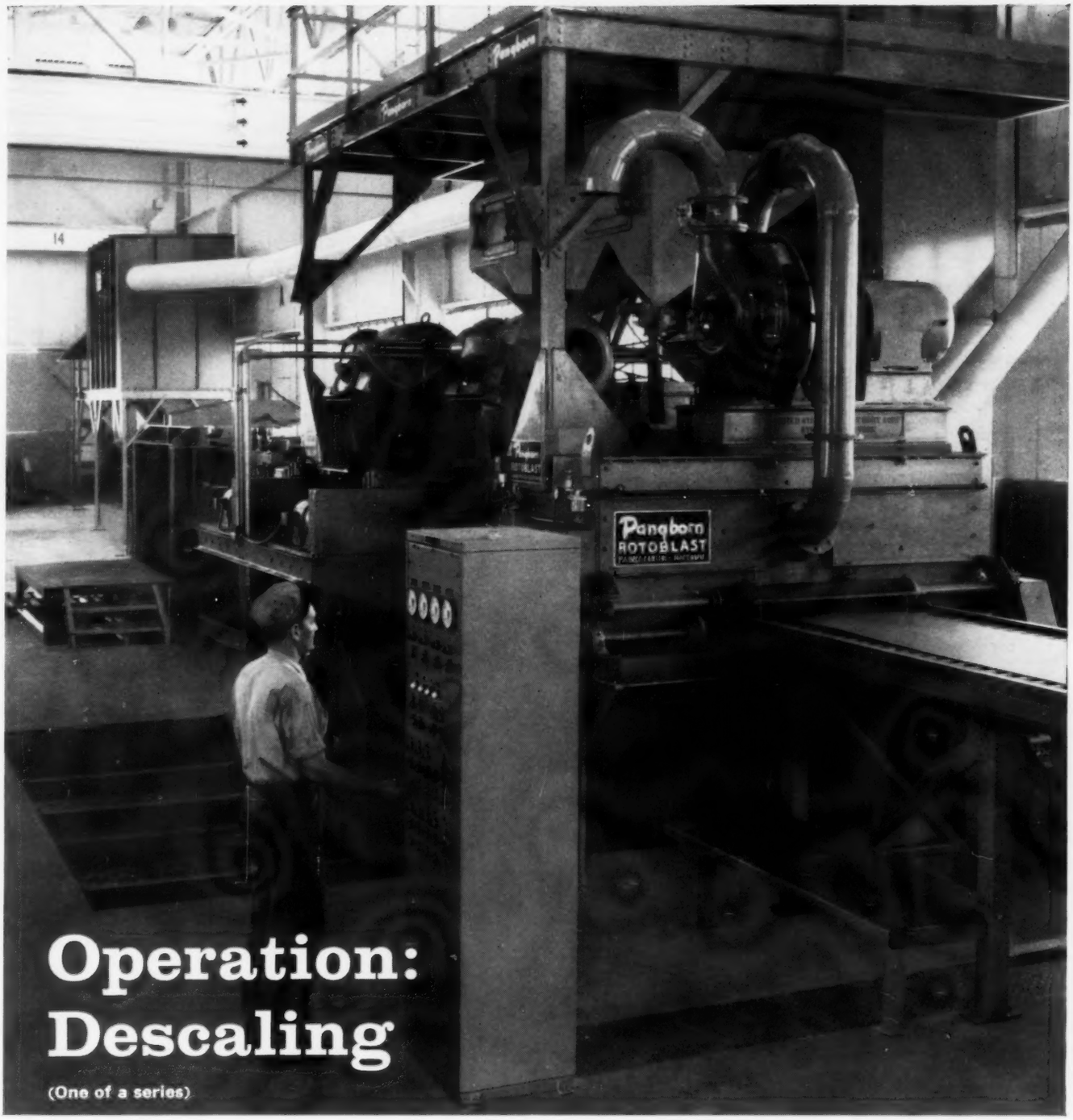
specialists in steel mill cranes and custom cranes of all types

YUBA-BEDFORD CORP.

1108 Fifth Street, Bedford, Indiana · A subsidiary of

YUBA CONSOLIDATED INDUSTRIES, INC.

Sales Offices in Atlanta • Buffalo • Chicago • Houston • Los Angeles • New York • Philadelphia • Pittsburgh • San Francisco • Seattle



Operation: Descaling

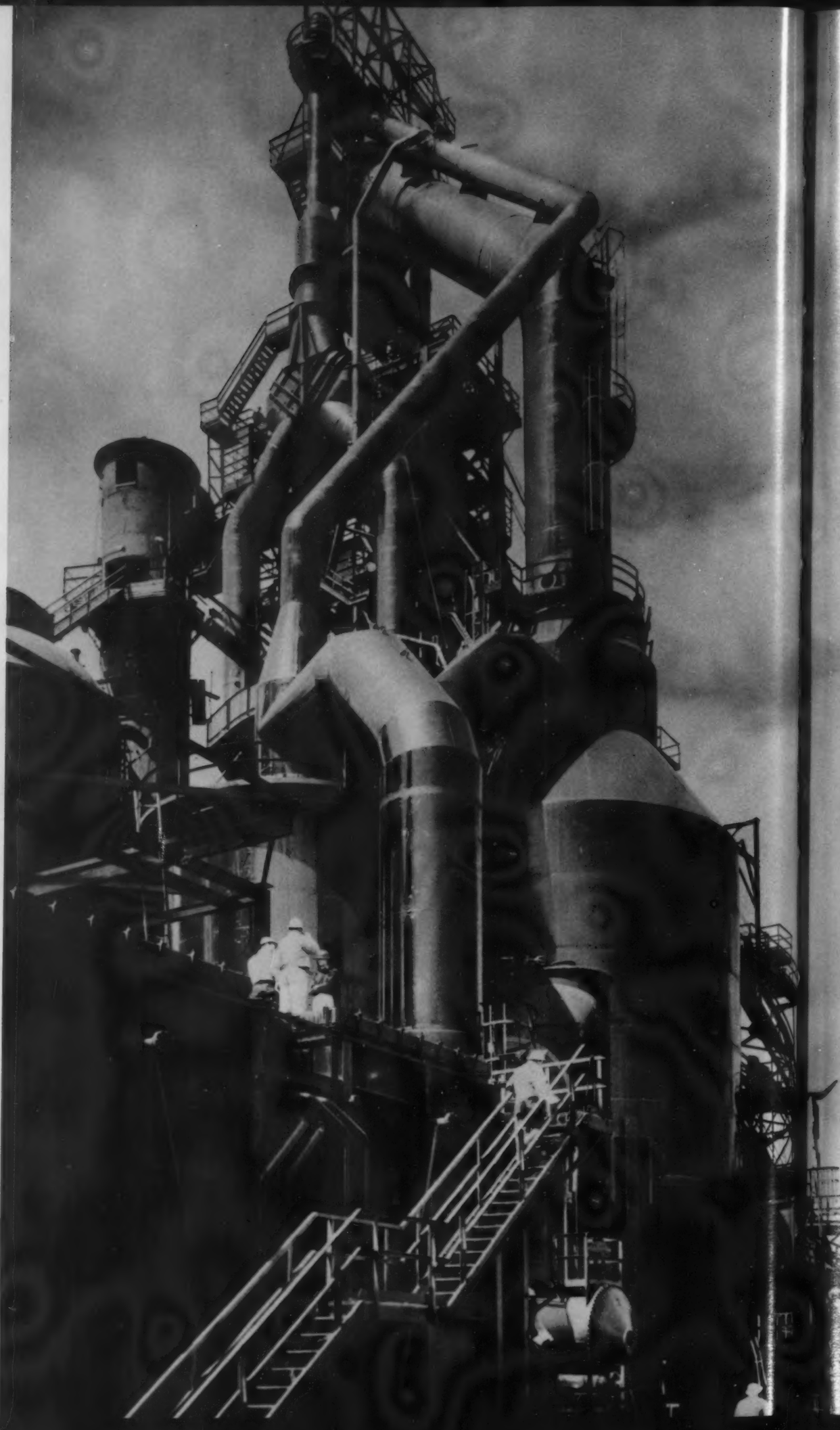
(One of a series)

Rotoblast Descaling pays off 4 ways!

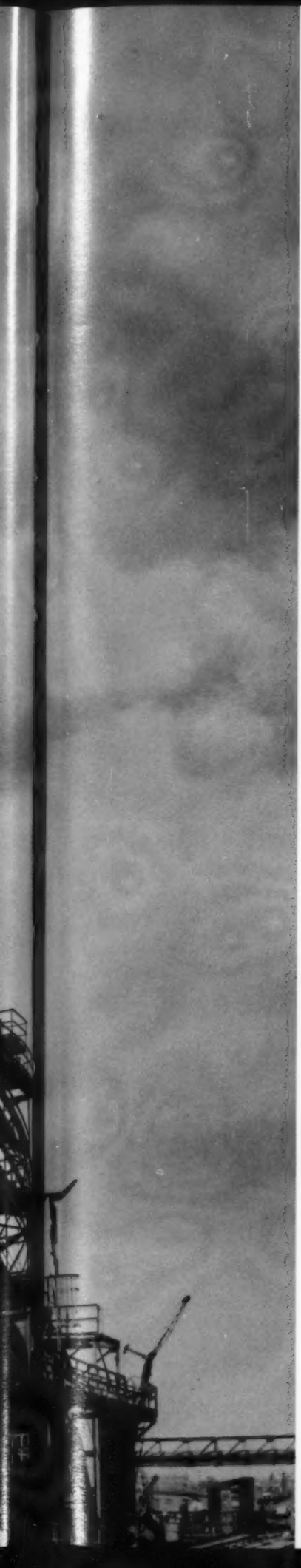
The Van Huffel Tube Co., Warren, Ohio, produces rolled shapes and welded tubing—some 2,000 shapes altogether. To descale strip coils before fabrication, Van Huffel uses a Pangborn Rotoblast Descaling Machine. And gains four ways! Now, by purchasing unpickled steel, the company gets better delivery. This improved delivery schedule permits a reduction in storage required for "slow delivery" emergencies. Also Rotoblast Descaling provides better paint adhesion on the finished surface. And descaling 4,000 to 5,000 tons a month, the Pangborn Rotoblast Descaling Machine cuts total descaling costs substantially.

How many ways can Rotoblast Descaling pay off for you? Talk to your Pangborn man or write today to PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning, Vibratory, Dust Control Equipment—Rotoblast® Steel Shot and Grit.®*

Pangborn
OF HAGERSTOWN



■ This is Furnace "A" at Great Lakes Steel Corporation's Zug Island plant — the first furnace in the world to cross the "30-foot line". Its hearth diameter is 30 feet, 3 inches.



MEETING THE COPPER NEEDS OF A GIANT

Furnace "A" of the Great Lakes Steel Corporation is *the* giant this side of the Atlantic—the first furnace in the world to cross the 30-foot barrier.

This magnitude justifies the special pride NBD feels about its contribution as one of the suppliers of Furnace "A" copper . . . a two-part contribution:

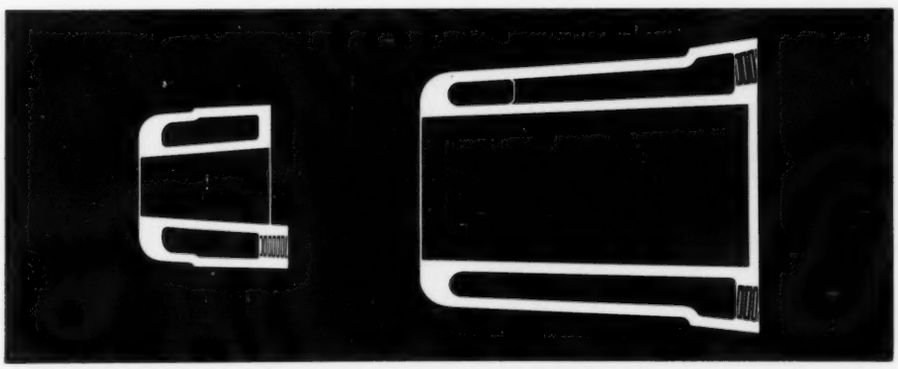
Customized Conductivity: NBD is recognized as the industry's leading advocate of this concept (reported here earlier this year).

At the Zug Island plant, the concept was put to use on monkeys and tuyeres. Working hand in glove, Great Lakes engineers and operating personnel and NBD copper specialists determined that a 90% minimum conductivity for monkeys would minimize "cutout". They also determined that, for the tuyeres, a controlled lower-conductivity copper with higher abrasion resistance would give adequate thermal flow while providing the necessary wear resistance, particularly at the nose.

These two distinct copper grades, customized to operating environment, have produced the desired results.

Quality Production: In view of its extensive manufacturing facilities, which have been supplying high-quality copper castings to the steel industry for more than 80 years, NBD won a berth as a supplier of monkeys and tuyeres for Furnace "A".

Put this combination of product engineering and quality production to work on all your blast-furnace copper needs. Through "customized conductivity" get the *right copper grade* and have veteran specialists cast it for you. You'll get the lowest possible copper cost per ton of iron produced. *Call us about it.*



NBD monkeys used in Furnace "A" (left) are cast of 90% minimum conductivity copper. NBD tuyeres (right) for Furnace "A" are giving long service life because they are cast of controlled lower-conductivity copper that has better abrasion resistance on the nose. These *two* grades of copper emphasize importance of NBD's "customized conductivity" concept.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

717-I Grant Building • Pittsburgh 19, Pennsylvania

...add years of service to your tanks and foundations

Sulphuric, hydrochloric, nitric or hydrofluoric acids... nickel salts or caustics... no matter what corrosive solutions your processes require, there is a Nukem cement designed for your service.

For over 35 years, Nukem has specialized in the manufacture of a complete line of acid and/or alkali proof cements and linings—each bearing the hallmark of "top quality." Over this same period—employing these products—the name NUKEM has been associated with successful, reliable, corrosion proof construction of Pickling Tanks, Neutralizing Systems, Foundations, Manholes, Trenches and Sewers.

Permanent, satisfactory results depend upon accurate analysis of the problem and selection of the exact material to meet every requirement. Proper design is essential and Nukem engineering "know-how" is at your service. For lasting and economical corrosion resistance, be sure you specify NUKEM.

NUKEM CEMENTS

- NUKEM BASOLIT
- NUKEM SILICATE CEMENT
- NUKEM SUPERTITE
- NUKEM ALL PURPOSE RESINOUS CEMENT
- NUKEM MULTIBOND CEMENT
- NU-KLAD

For information and illustrated technical data write:

NUKEM PRODUCTS CORP.

Dept. 5K • 4809 Firestone Boulevard • South Gate, Calif.

A Subsidiary of Amercoat Corp.

N 102

Photo courtesy Jones & Laughlin Steel Corp., Aliquippa (Pa.) Works.

FOR EVERY APPLICATION, THERE'S ONE CRANE OUTSTANDING...

IN PIPE MILLS: One of many P&H overhead cranes installed throughout the mill area, this P&H double-hook crane provides cat-quick but kitten-gentle handling of long and awkward loads of pipe. The twin-lift arrangement is typical of the complete attention P&H engineers give to custom-building cranes to your exact requirements. This means maximum crane efficiency with minimum operating costs because *your* P&H overhead crane is specially tailored for *your* job.

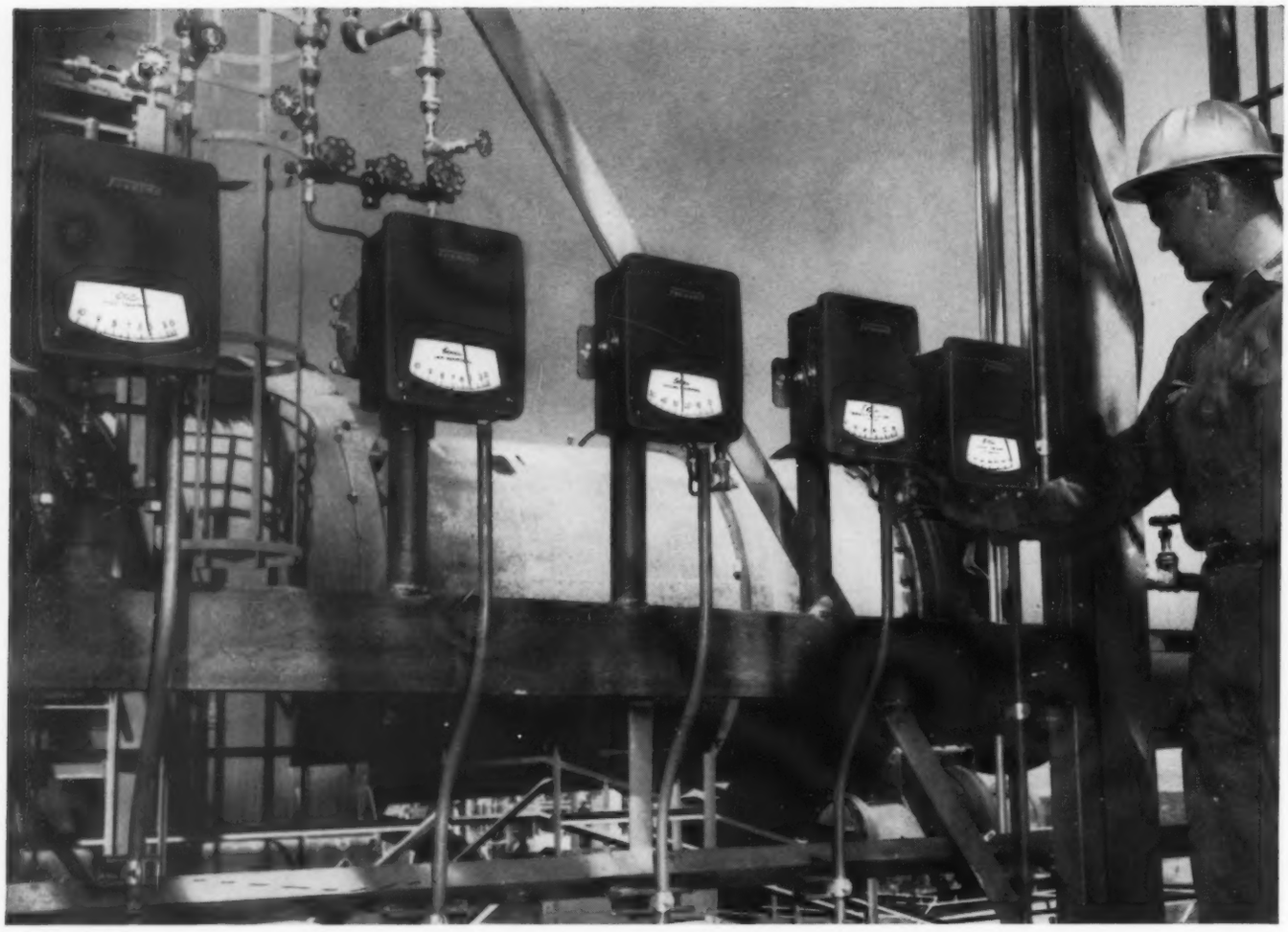
If you'd like more reasons why satisfied customers have made P&H the largest manufacturer of overhead cranes in the world, write for your free, information-packed copy of Bulletin C-42 to Dept. 111, Harnischfeger Corp., Milwaukee 46, Wisconsin.

P&H deep carburized gearing as well as bridge and trolley wheels are available as an option where service is particularly severe with frequent impact or shock loads. These two cross-sectional views clearly show how P&H's special heat treatment produces exceptionally hard wearing surfaces combined with a tough ductile core.

Sectional views of deep carburized wheel and gear

P&H
OVERHEAD CRANES

HARNISCHFEGER



Type 630 indicating electronic Consotrol transmitters may be equipped with any standard Foxboro measuring element. Transmitters continue to measure and indicate even in event of power failure.

Temperature, flow, pressure, level – Foxboro Electronic Transmitters will measure and transmit them any place wires can go

FOR DISTANCES up to several miles, Foxboro Electronic Consotrol* Transmitters are the fastest, most accurate way you can transmit a measured variable.

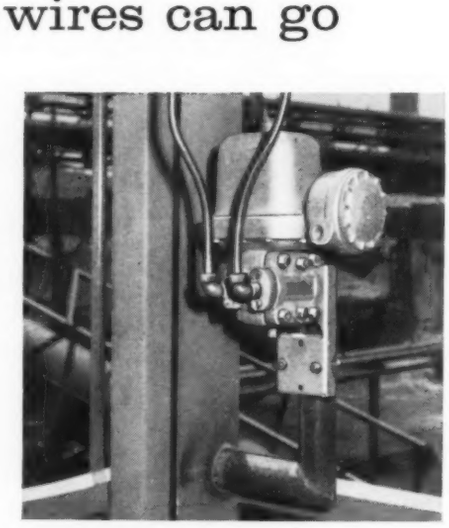
There's no transmission lag. Electric signals are transmitted instantly over two small, unshielded wires to centrally-located recorders and controllers.

Both the Foxboro Indicating and Force-Balance Electronic Transmitters have no vacuum tubes to burn out. Instead, dependable, solid-state components are used throughout to insure years of trouble-free operation.

Zero and span settings are simple mechanical adjustments. And your present personnel will need no special training or skills to operate them.

Foxboro Electronic Transmitters can be mounted anywhere — in any position. Heavy-gauge, tight-gasketed cases completely protect them from dust, dirt, and weather.

Ask your Foxboro Field Engineer how they can help improve the efficiency of your operation. Or write for Bulletin 21-10 — it tells the whole Electronic Consotrol story. The Foxboro Company, 5811 Neponset Ave., Foxboro, Massachusetts.



Type 613 d/p Cell* transmitter combines simplicity and accuracy of force-balance with speed and convenience of electrical transmission. Requires no power supply at the transmitter.

Reg. U. S. Pat. Off.

FOXBORO

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Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

"Mechanism of Grain Refinement by Low-Frequency Vibrations During Crystallization [of Metals]," by I. I. Novikov et al., Izvest. VUZ—Chern. Met., May, 1960, No. 5, pp. 130–134. Inconsistency of literature data on the mechanism underlying the effect of low-frequency vibrations on size and shape of grain of solidifying metals. Experimental setup used in authors' laboratory study of this mechanism, based on visual observation, ordinary and cinephotomicrography of crystallization patterns obtained after various lengths of time in the absence and presence of vertical and horizontal vibrations. Conclusions drawn from results as to the true effects of low-frequency vibration upon cast metals in process of solidifying. (Translation No. 4900)

"Casting of Metals with the Pouring System [Instead of the Mold] Being Vibrated" by G. F. Balandin et al., Liteinoe Proizvodstvo, July, 1960, No. 7, pp. 34–36. Study of effect of vibrating the metal as it flows into the mold, upon the quality of the castings. Experimental setup with the ingate or the runner vibrated. Results obtained with 4½-lb aluminum ingots. True mechanism of grain refinement in castings made under vibration. Data on susceptibility to hot cracking; specimen shape; effect of vibration. Experimental proof in support of authors' unique theory about grain refinement mechanism under vibration. Advantages of vibrating parts of the pouring system over vibrating the mold. Applicability of proposed vibrating technique to molds of any shape, including those used in continuous and semi-continuous casting. (Translation No. 4908)

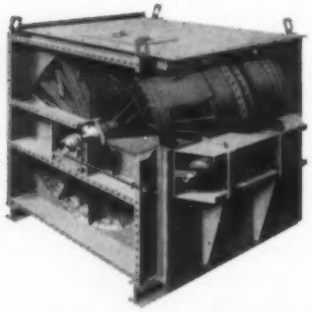
"Organization of Production of Electric Steel by Duplexing," by S. P. Edneral, Prim. Kis. Metallurgii (Use of Oxygen in Metallurgy) by I. P. Bardin, edit., Moscow, 1957. Problem of idling time of electric arc furnaces when supplied with liquid metal from open hearth furnace during periods of scarcity of good-quality pig iron or scrap, or electric power. Successful expansion of electric steel production in Germany by using a low-carbon semiproducts (0.019 per cent N) from basic-lined converters. Advantages of using metal top-blown in basic converter to a low C and low N (0.005 to 0.007 per cent N) content for electric furnace; ease of synchronizing converter with arc furnace production. (Translation No. 4836)

"Refining of Open-Hearth and Semi-Basic-Converter Pig Irons by Oxygen Top-Blowing," by Z. Zdeněk et al., Hutnicke Listy, vol. 14, 1959, No. 12, pp. 1073–77. Report on pilot-scale refining of basic (open hearth) iron, and semi-basic-bessemer irons containing ½ to 1.1 per cent P in a 5 metric ton oxygen-top blown LD-type furnace. Details on design and operation of furnace. Refining of basic (open hearth) iron; ore vs scrap cooling; lime, oxygen, etc., consumptions; slag volume; composition of hot metal and of finished seamless tube steel. Importance of a process suited for the refining of pig irons containing up to 1.1 per cent P; composition of hot metal and finished steels made from them; single vs double-slag practice; P_2O_5 content of slag. Particulars on oxygen, nitrogen, sulphur, and phosphorus contents of steel from LD-type furnace. Uses of such steels: deep-drawing sheet; steel wire; and tubes; comparison of quality with that of ordinary open hearth steel. (Translation No. 4773)

"Horizontal Continuous Casting Plant For Large-Tonnage Steels," by R. Dawirs, Stahl und Eisen, vol. 80, 1960, No. 7. Limitations to output with vertical continuous casting installations for steel. Exploration of possibilities of horizontal continuous casting, aimed at a simple plant, low investment costs and high outputs of the cheaper steels. Original semi-continuous casting setup used. Development work on a suitable mold to eliminate jamming and transverse cracking of bars cast. Results of several series of experiments. Outline of necessary future development work. (Translation No. 4814)

NEW...FOR STEEL PROCESSING FURNACES

continuous regenerative Air Preheaters



THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

1. The Ljungstrom® Metallic Rotary Regenerative Air Preheater has had widespread use in this country, in the industrial and utility fields since 1925. Over 3500 units are now in operation. These include those of high temperature alloy design for refinery installations.

2. Now we are prepared to apply our regenerator to steel plant furnaces, particularly to proposed reheat furnaces and soaking pits. Because of its compactness and layout flexibility, the Ljungstrom also might well be considered for up-grading existing furnace capacities by raising preheated combustion air temperatures.

3. For your study and analysis, we would like to offer our services in selecting a suitable preheater and submitting its performance and cost for any given application. To accomplish this, we request that you send us the following data:

1. Type Furnace_____

2. Fuel Type_____ Heating Value_____ Cost_____

3. Fuel Rate . . . BTU/HR_____

4. Ambient air temperature . . . °F_____

5. Flue gas temperature . . . °F_____

6. Desired combustion air temperature . . . °F_____

HIGH-PRESSURE JETS BLAST DEPOSIT-PACKED BUNDLES CLEAN AS NEW

The high-pressure jet unit below is blasting solidly-caked deposits from a heat exchange bundle . . . removing substantially all traces of deposits throughout the bundle, without cutting it apart!

Nation-wide Dow Industrial Service developed this automatic unit to remove scale, coke and asphalt deposits without metal erosion or wall thinning. This is just one of many advanced tools and techniques developed by Dow Industrial Service to clean equipment of every kind... boilers, pipelines, chemical process equipment, towers, scrubbers.

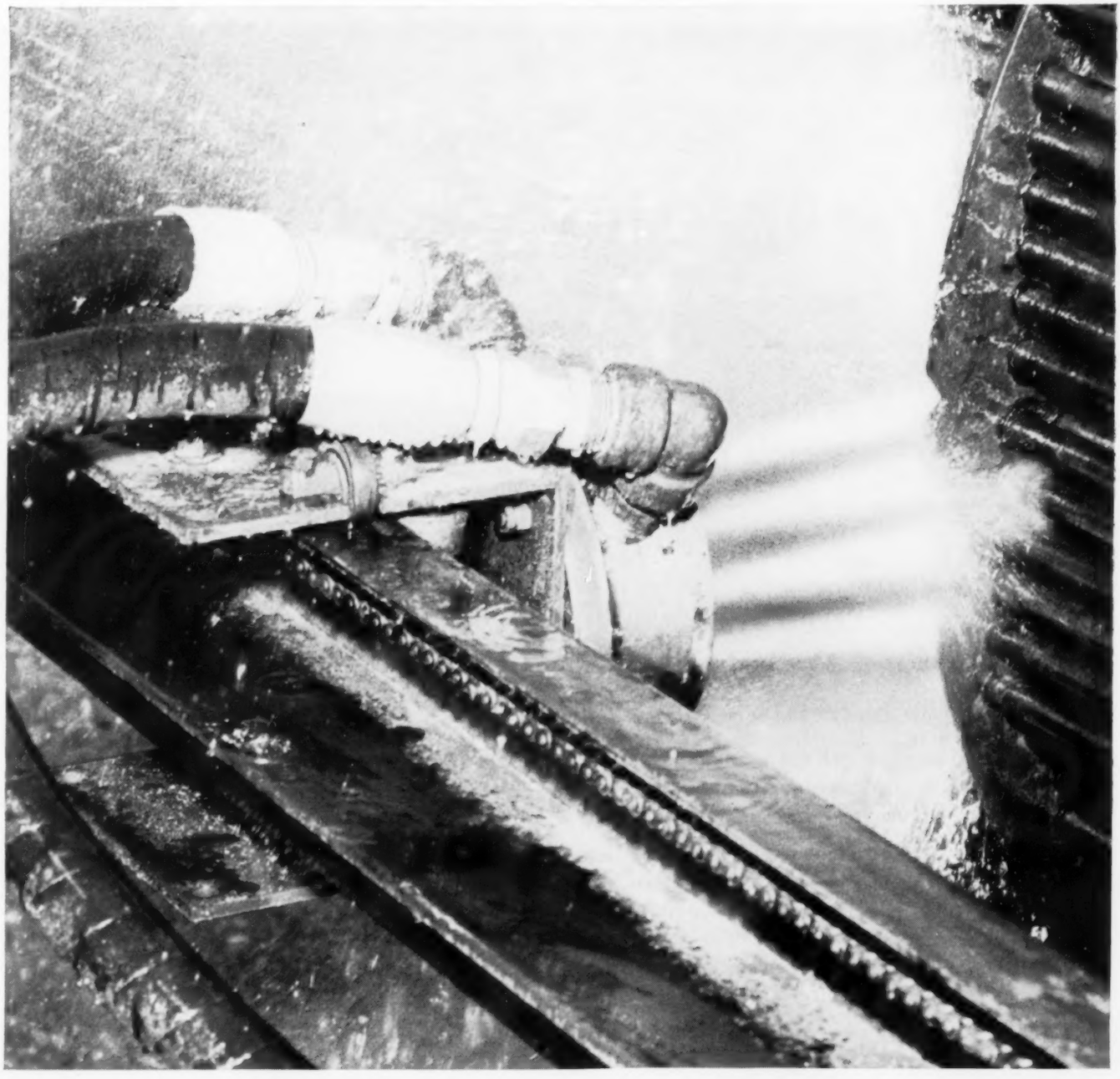
D. I. S. engineers first analyze your problem, then pick the most effective cleaning method . . . whether chemicals, steam, jet, foam, or other means. D. I. S. tailors the technique to give you most value per dollar.

In addition, D. I. S. offers complete consulting laboratory service for water treatment and waste processing problems, backed by the technical resources of The Dow Chemical Company.

D. I. S. is a nation-wide industrial service . . . and offers "total" cleaning. For cleaning equipment of *any* kind, *anywhere*, call D. I. S. We'll be glad to show you how to set up a year 'round cleaning program to *keep* equipment operating at top efficiency. Write or call DOW INDUSTRIAL SERVICE, 20575 Center Ridge Road, Cleveland 16, Ohio.

DOW

DOW INDUSTRIAL SERVICE • Division of The Dow Chemical Company



Automatic jet unit removes bundle deposits, without dismantling.

Another *plus* of Lightweight B&W Insulating Firebrick

LOWER THERMAL CONDUCTIVITY means

THERMAL CONDUCTIVITY COEFFICIENT*

B&W • IFB • 1.91

Competitive IFB • 3.04

NOTE: The above chart, based on available published figures, compares the difference in thermal conductivity between lightweight B&W IFB and the average of seven other leading insulating firebrick. This example, specifically covering 2300 F use limit insulating firebrick, is representative of the low conductivity of B&W IFB at all temperature levels.

*BTU/SQ. FT./IN. THICKNESS/HR./DEG. F.

All insulating firebrick are not the same. Published figures show wide variations in *all* of the important properties among the leading brands of IFB.

Take thermal conductivity. This important property affects fuel costs, temperature control and the speed with which a furnace heats and cools. Thermal conductivities range from a B&W low of 1.91 to a high of 3.47 for a competitive IFB—*almost a 100% difference in wasted heat and fuel costs.*

You are paying for insulating firebrick . . . make sure you get *all* the benefits. B&W—the originator of IFB—manufactures a full line of IFB with an experience-proved balance of light weight, high insulating value, high strength and long life.

For complete information on B&W Insulating Firebrick, write for Catalog R-2-H to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

NUMBER 1 OF A SERIES

LOWER FUEL COSTS

the payoff

- **14% lower fuel costs • 30 F lower casing temperature**
- **25% less time to reach operating temperature • 12 hours saved per cycle**

These are the results of a direct comparison of two furnaces of the type shown above, one lined with B&W IFB and the other with one of the better competitive insulating firebrick. That's how B&W pays off for a major steel company in their 8-stack, hood type, strip annealing furnaces. This is just one of many proofs in our files that "there is an important difference in insulating firebrick."

R-658

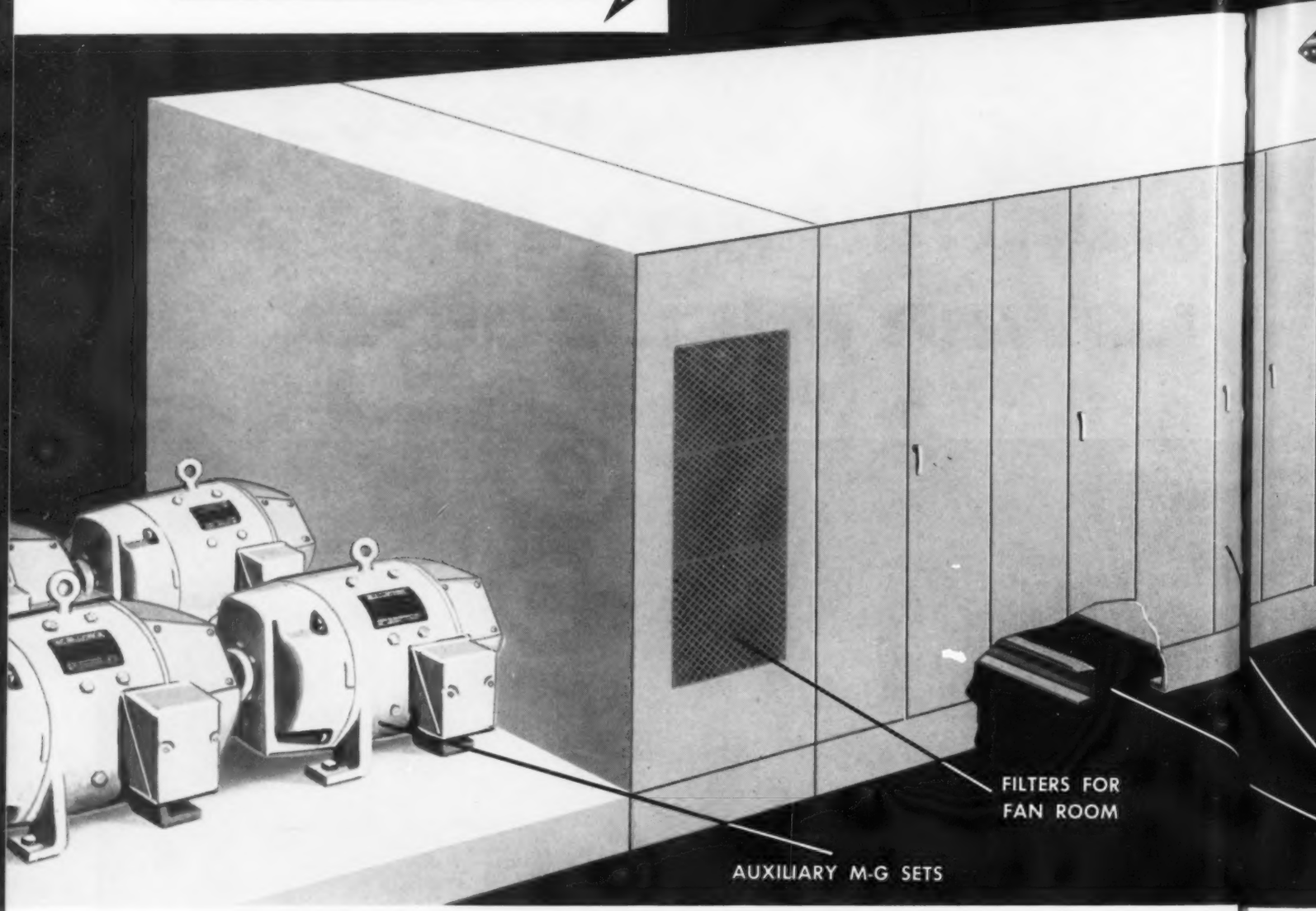
B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

FOR QUALITY... PRODUCTIVITY ... PROFIT

METAL ROLLING AUTOMATED BY GENERAL ELECTRIC



A NEW PRACTICE IN PROCESS-LINE CONTROL

G-E "packaged" motor-control rooms reduce

The latest innovation in modern steel-mill process-line control is General Electric's new "packaged" motor-and-control room. This novel design, developed jointly by General Electric and Jones and Laughlin Steel Corp., groups all controls and m-g sets into one compact centralized unit. The above unit will be installed at J&L's Aliquippa, Pa., works, as part of their continuing facilities-improvement program. Previously, the installation expense on this equipment often matched or exceeded the actual cost of the equipment. The new G-E motor-control room design cuts installation costs as much as 40 percent!

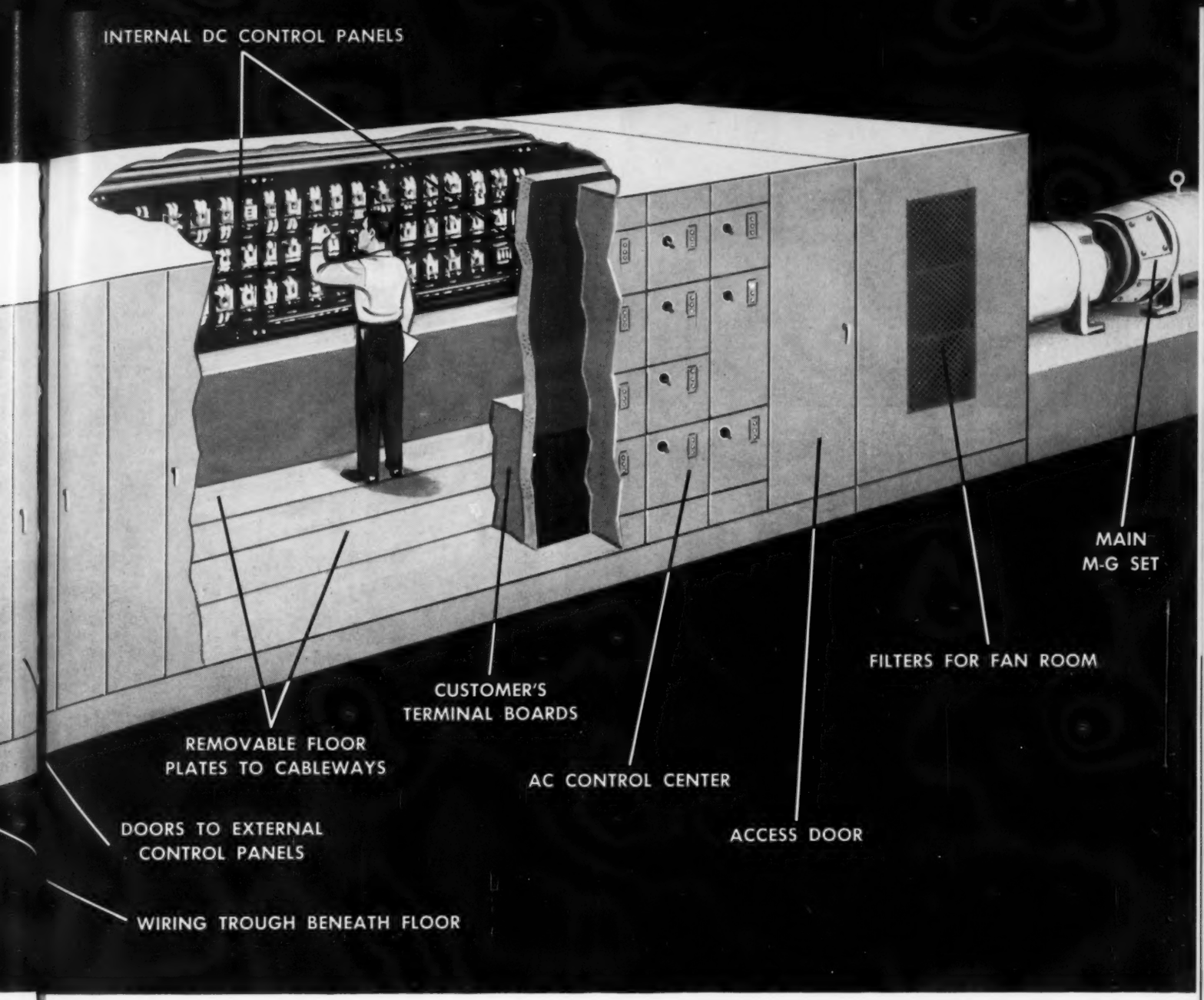
HERE'S WHY INSTALLATION COSTS ARE LOWER

Substantial savings on installation expenses can be realized through these features:

Independent control unit—The General Electric motor-control room is a completely co-ordinated, pre-assembled unit in itself, and in many cases, eliminates the need for a separate motor room. Since the motor-control room is self-contained, it may be located either near the driven equipment or in some previously unused area of the mill.

Field wiring is reduced by one-third or more—All internal connections are made and tested before the motor-control rooms are shipped. The only field wiring required is the connection of the power source and the leads to the operators' stations and the drive motors.

Construction engineering costs reduced—General Electric's grouped control concept enables the mill to know its conduit requirements much sooner. Thus, fewer,



installation costs as much as 40 percent!

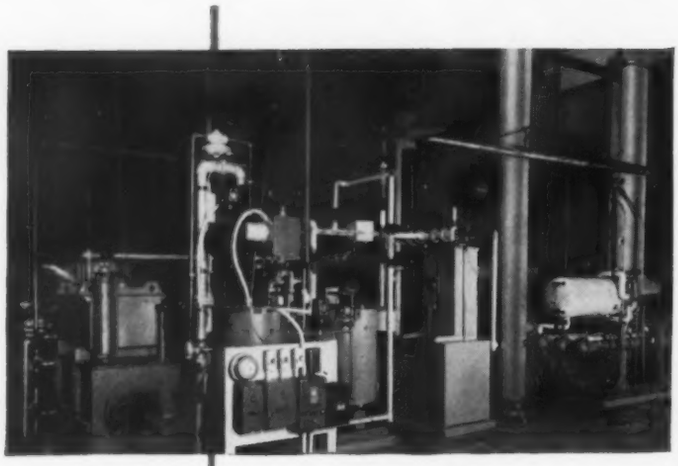
less-complex construction diagrams are needed, and actual construction can begin at an earlier date.

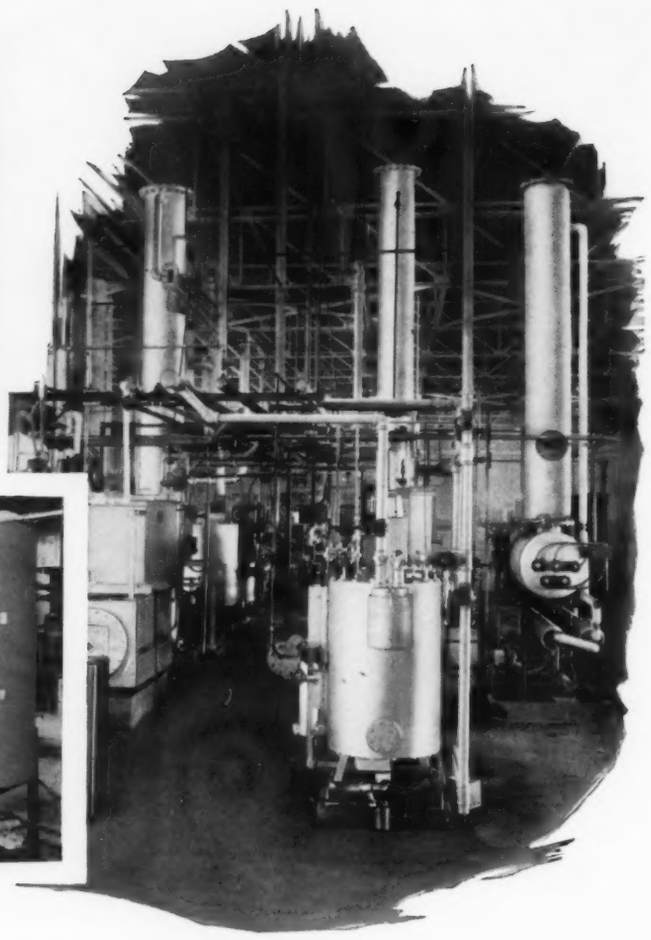
Common base minimizes installation time—This new "packaged" motor-control room, delivered on its own self-supporting platform, can be immediately set on a normal mill floor. It does not require expensive, specially-constructed foundations. With m-g sets built and shipped on a common base, the need to align them at the mill site is eliminated. In addition, regulating equipment is factory-tested prior to shipment, further expediting startup time.

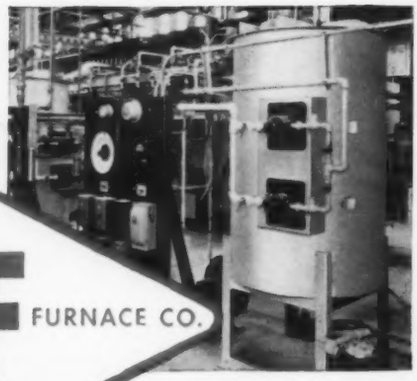
For all the details on this new technique in process-line control, contact your G-E Sales Engineer today! General Electric Company, Industry Control Department, Salem, Virginia, and Direct Current Motor and Generator Department, Erie, Pennsylvania. 785-7

Progress Is Our Most Important Product

GENERAL ELECTRIC







THE ELECTRIC **EF** FURNACE CO.

GAS • OIL • ELECTRIC

Protective Atmosphere Equipment

Exothermic and Endothermic Generators, Ammonia Dissociators, High Nitrogen and High Hydrogen Generators, Refrigerators, Dryers, Desulphurizers, CO_2 Scrubbers, and Auxiliaries, for Industrial Furnace Processing.

Get the exact surface characteristics you need, with unvarying uniformity day after day and month after month, with EF special atmosphere equipment.

EF engineers pioneered the development and use of exothermic, endothermic, and other low cost atmospheres, and have been leading manufacturers of this equipment continuously since that time.

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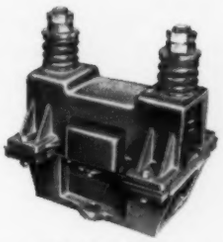

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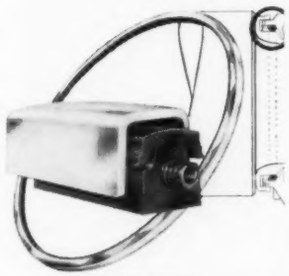

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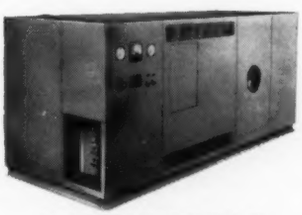

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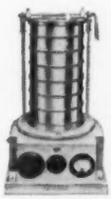

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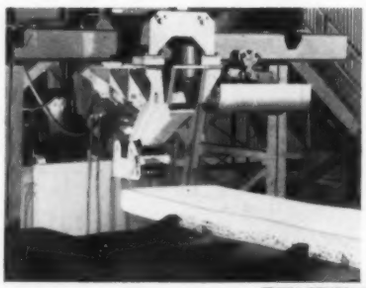
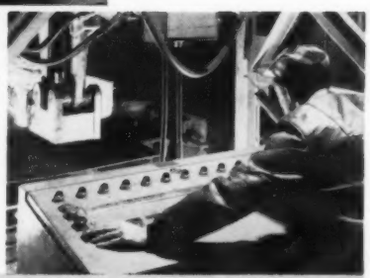


Slab in position for stamping with pneumatically-powered marking head. Both blooms and slabs are marked by the machine at J & L.



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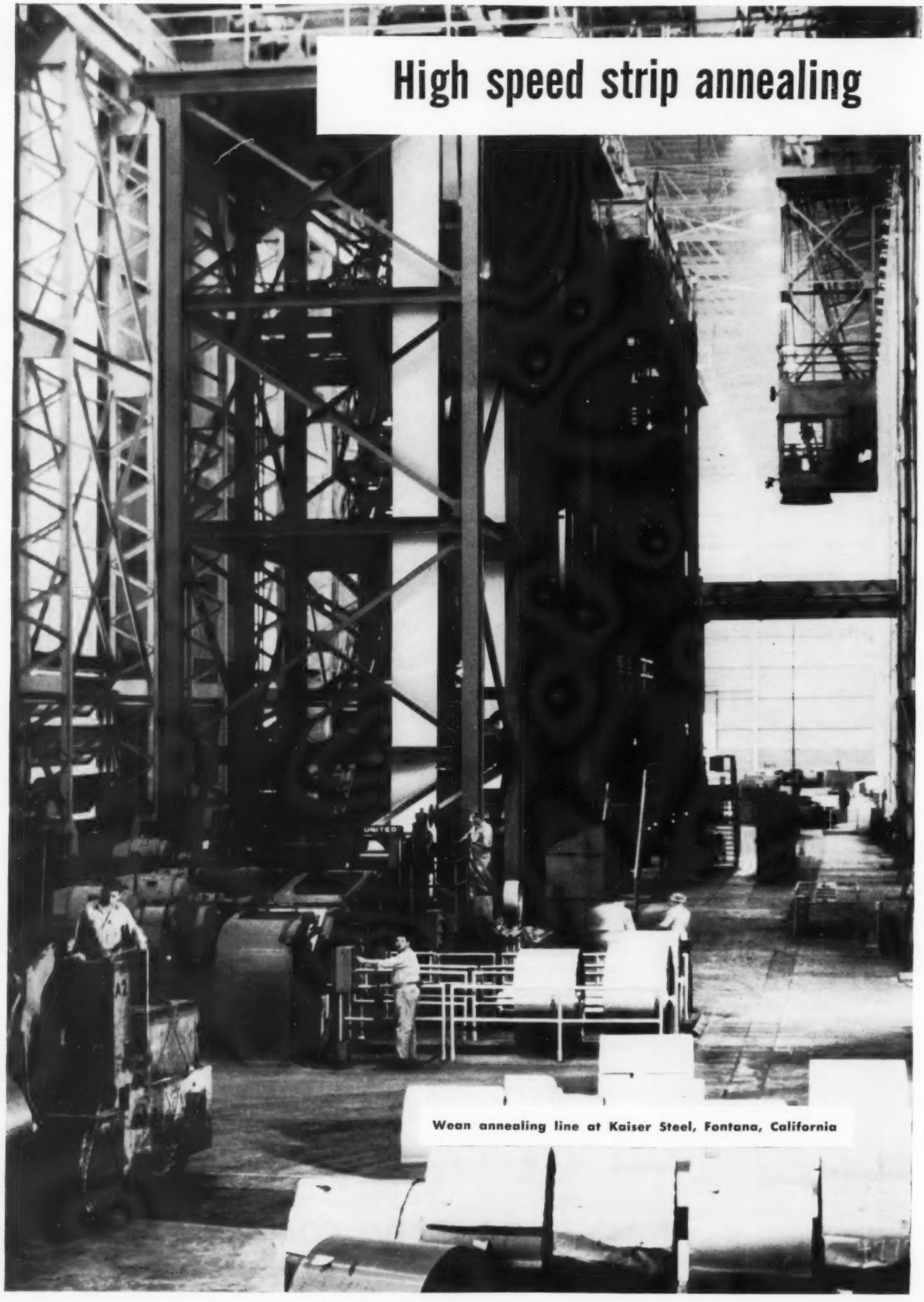
UNION CARBIDE

High speed strip annealing



Wean annealing line at Kaiser Steel, Fontana, California

gives steel makers major cost and product benefits

Evolution of process gets major assist from Reliance's creative engineering

Speeds up to 2,000 feet per minute, thinner gauge steel, greater annealing uniformity, and higher tonnage output are the chief reasons for the spread of this process. Actually, lines like this one at Kaiser Steel can handle gauges from .0150″ down to .0070″ in coils up to 90″ outside diameter and widths of 42″ or greater . . . reducing costs in a growing tinplate industry.

Associated electrical equipment must be upgraded to meet the call for higher yield annealing lines. Reliance engineering is presently meeting that challenge. Here are some of the ways:

Furnace tension control

On advanced Reliance systems, the exit bridle is the lead and overall furnace tension is maintained by the entry bridle. Maximum line flexibility is provided, since the entry bridle can be position-controlled or tension-controlled. In tension-control, a regulator monitors the bridle torque, maintaining it at the pre-set level.

For position-control, a torque-regulated furnace tension unit position-controls the entry bridle. The tension unit consists of a short loop provided by a loaded roll, the position of which modifies the speed of the entry bridle. The roll may be locked in position when the bridle is directly controlling strip tension.

Helper drive torque regulation

Since it is economically unfeasible to regulate each of many furnace helper motors, the helpers have been grouped by furnace function (heat section, hold section, slow cool and fast cool). Each group is torque-regulated and each motor held within a group can be adjusted manually to take its share of the load while the entire section automatically holds its relative load position with respect to other sections. Reliance has encouraged the use of this system.

Reliance also strongly recommends the equipment explained below:

Strip-tension measuring load cells

These measure the strip tension existing at the exit end of each furnace section. Associated recording meters enable the operators to relate strip quality and elongation to helper drive torque settings of each section for different conditions of speed, gauge, etc.; in other words, able to study various settings of torque—and be able to repeat those which give the best results.

Automatic furnace tension control

The load cells provide an output signal which *can* be used as an input to the section torque regulators to maintain continuously desired tension. Correct inertia compensation for line speed changes is inherently provided by this system.

Synchro-control of looping tower

This eliminates inaccessible or hard-to-service photo-electric elements. A synchro is used to indicate and regulate tower position.

Automated strip feed-up

This increases the efficiency of entry end material handling, allowing high furnace speeds to be maintained.

It will pay you to discuss with Reliance engineers some of the fine points of annealing line system controls and drives. Creative application engineering, plus the ability to assume total responsibility through start-up and service are the reasons why Reliance is so readily acceptable at engineering, production and management levels of industry. Call your Reliance Sales Engineer. He has an office near you. If you prefer, write for Bulletin L-2513.

L-1672-BW

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

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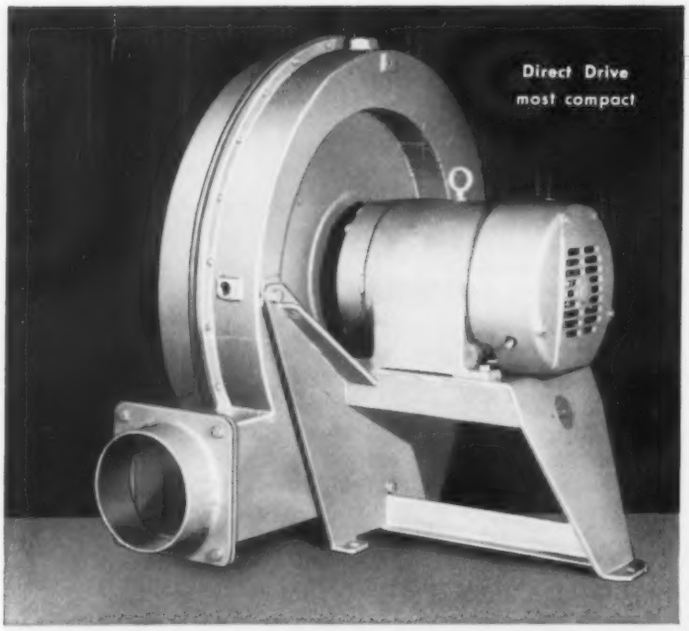

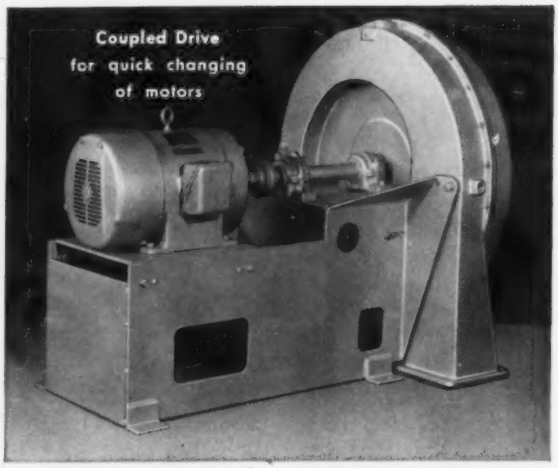

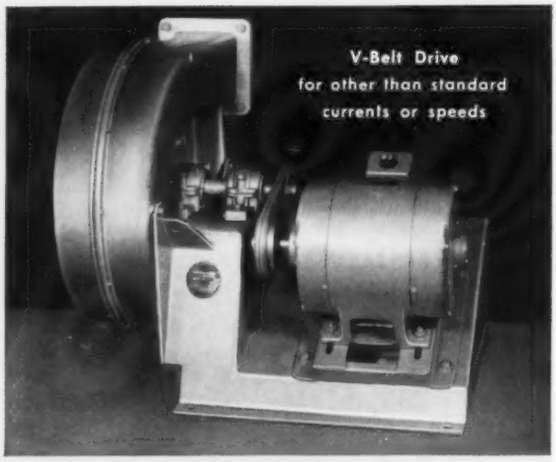

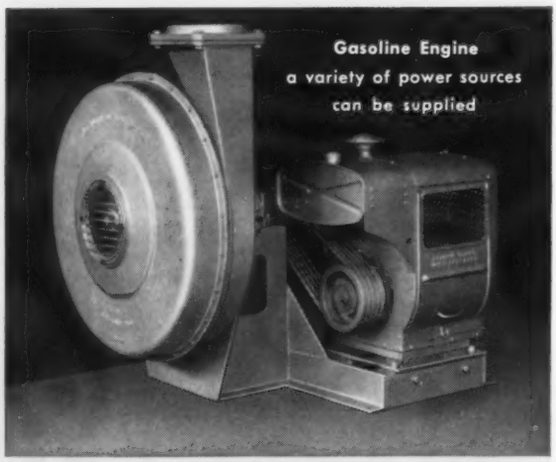

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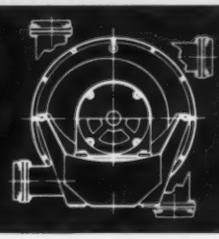

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J&L STEEL

Jones & Laughlin . . .

ALIQUIPPA WORKS

J&L STEEL

Jones & Laughlin ... ALIQUIPPA WORKS

By T. J. Ess

SHORTLY after the start of the present century, Jones & Laughlin Steel Co., which had just been formed by the merger of Jones & Laughlin's Ltd. and Laughlin & Co., Ltd., had reached annual capacities of more than 1,000,000 tons of iron and 1,000,000 tons of steel. Production facilities were located on opposite sides of the Monongahela River in the city of Pittsburgh, which by that time had ground around the plants, hemming them in.

Since further expansion was desired, particularly in order to broaden the variety of products, it was deemed necessary to build elsewhere. In 1905, land was acquired at Woodlawn, Pa., about 20 miles down-river from the Pittsburgh plant. The site had been an amusement park and farmland. Ground was broken for the new plant in 1907. To help pay for this large project, the company borrowed $20,000,000 on mortgage bonds.

The first blast furnace was completed in 1909. Two more were finished in 1910, a fourth in 1912, and a fifth in 1920. Construction of steel producing and rolling facilities began in 1909. Tinplate was first rolled in 1910. Open hearth steel was first produced in 1912 and bessemer steel in 1914. By 1912, the plant had a capacity of 250,000 tons of ingots per year, and by 1930, the annual capacity had grown to 1,420,000 tons of ingots. Products were principally billets, merchant bars and shapes, welded pipe, tinplate and wire. Seamless tube production started in 1927.

In 1947, continuous strip pickling and cold reducing facilities were installed for tinplate production, using hot rolled coils from the Pittsburgh Works. Also since World War II, a new rod mill was installed, replacing two old mills, new coke ovens have been constructed, the blooming mill was rebuilt and electrified, a semi-

continuous hot strip mill was put in, basic oxygen steelmaking facilities were added and mills for electric-weld and continuous butt weld pipe were installed.

Today, Aliquippa Works occupies a site of 475 acres extending for about five miles between the left bank of the Ohio River and the Pittsburgh & Lake Erie Railroad. The location provides excellent transportation by river or by rail for raw materials and products. The plant has annual capacities for 1,935,000 tons of by-product coke, 2,090,000 tons of iron, 1,164,000 tons of open hearth steel, 384,000 tons of bessemer steel and 880,000 tons of basic oxygen steel. Its products include strip, bars, rods, structurals, skelp, tube rounds, hot and cold rolled sheet, black plate, electrolytic tinplate, hot dip tinplate, wire (plain, galvanized, barbed, nails and staples), woven wire fence, continuous buttweld and electric-weld pipe, seamless tube, galvanized pipe and mechanical tubing.

RAW MATERIALS

Iron ore for the Aliquippa plant comes principally from company-owned properties on the Mesabi range in Minnesota and the Marquette range in Michigan, and the Benson Mines in New York. Some Mesabi ore is also purchased. The Lake ores are graded at the harbor by mixing them in varying proportions to form ore groups of the desired analyses. The Lake ores are shipped by carriers to lower lake ports and transferred into railroad hopper cars for shipment to the plant.

The New York ore is beneficiated and sintered at the mine and shipped by rail throughout the year. It is a bessemer magnetite grade.

A small amount of magnetic bessemer pellets is received from the Hilton mine in Quebec, Canada. The company is part-owner of this mine and receives 25 per cent of the output. These shipments are also by rail throughout the year.

About 50 per cent of all Lake ore received has been hydraulically washed, 20 per cent dry screened and 30 per cent untreated. The fines from the treating operations are also shipped to the plant to be sintered.

Analyses of the ores and sinters used at Aliquippa are given in Table I.

With full operations, the Aliquippa Works uses about 3,600,000 tons of iron ore and sinter per year, of which some 80 per cent comes from the Lakes ranges.

As ore is received at the plant, the cars are put through a 105-ton car dumper which unloads the ore into four 70-ton transfer cars. These cars carry ore directly to the stockhouse bins to a pit at the ore yard, where three ore bridges stock it in the yard, or to the sintering plant. The ore yard, 300 ft wide x 2000 ft long, offers storage capacity of approximately 1,500,000 gross tons.

Some limestone is quarried at a company-owned property at Martinsburg, West Va., and some is purchased from quarries in Pa. Dolomitic stone comes from company-owned quarries at Millville, West Va. Analyses are shown in Table II. The stone is sized into several classifications, from $\frac{3}{4}$ in. minimum to 5 in. maximum. Most of the stone from company-owned properties is also washed. Stone is received by rail and usually unloaded directly from the high-line trestle into the stockhouse bins. About 2300 tons of limestone are used per day at Aliquippa.

High volatile coal comes from company-owned mines in southwestern Pa., while low volatile is purchased

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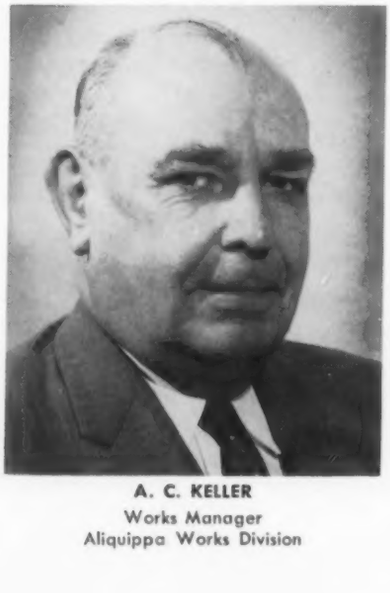
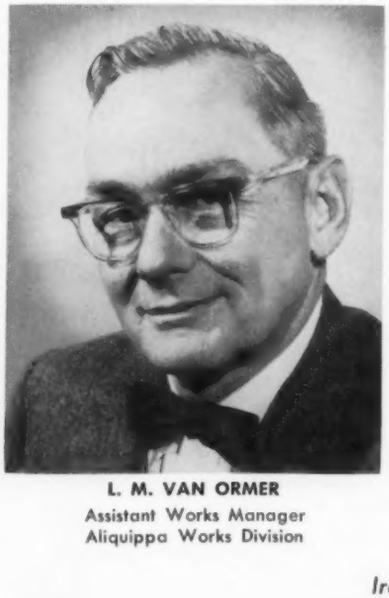
from mines in southern West Virginia. Table III gives average analyses. The coals are washed at the mines, and come to the plant by river barge.

Metallurgical coal is normally unloaded at a river dock, using a double bucket line hoist of 1500 tons per hr capacity. As the coal is hoisted from the barge, it is crushed to −5 in. and delivered by belt conveyors to any one of four 500-ton surge bins which permit the hoisting of different coals to clean bins without mixing or delay.

Metallurgical coal intended for storage and boiler coal are usually unloaded at a second river dock. Here a 400-ton-per-hr double bucket line hoist lifts coal from the barge and delivers it to a crusher set at 4 in. From the crusher, steam coal for immediate use is delivered by conveyors either directly to boiler house bins or to cars for distribution by rail. Coal (either boiler or metallurgical) to be stocked is moved by conveyor to a coal storage yard. This yard is 300 ft wide x 1200 ft



A. C. KELLER
Works Manager
Aliquippa Works Division



L. M. VAN ORMER
Assistant Works Manager
Aliquippa Works Division

J. M. GEHR
Ass't to Works Manager—Personnel Relations
Aliquippa Works Division

TABLE I
Iron Ore Analyses
(Natural basis)

	Minnesota		Michigan	New York	Aliquippa	Canadian
	basic	bessemer	basic	bessemer	sinter	pellets
Fe	54.01	55.26	52.53	64.04	54.89	64.35
SiO_2	8.31	10.74	7.10	5.44	9.75	2.06
P	0.057	0.036	0.075	0.023	0.043	0.005
Mn	0.38	0.34	0.28	0.26	0.20	0.08
Al_2O_3	1.16	0.69	2.47	2.78	1.52	0.48
CaO	0.08	0.09	0.66	0.23	4.50	0.35
MgO	0.07	0.07	0.97	0.26	1.79	1.21
S	...	...	0.31	0.03	0.021	...
H_2O	7.86	5.37	10.94	7.60	3.15	3.23

TABLE II
Limestone and Dolomite Analyses

	Limestone		
	J&L	Purchased	Dolomite J&L
SiO_2	1.50	2.25	1.44
Al_2O_3	0.75	1.65	0.72
CaO	53.00	52.60	31.12
MgO	1.45	0.56	20.20
P	0.009	0.023	0.009
S	0.060	0.046	0.036

TABLE III
Coal Analyses

	Vesta-Shannopin	Amonate
H_2O	7.9	6.0
Volatile	36.53	24.25
Fixed carbon	56.59	69.29
Ash	6.88	6.46
Sulphur	1.67	0.64

long. It is served by a coal bridge running the entire length with a shuttle conveyor for putting coal into storage and a bucket elevator for reclaiming. The bridge will stock at 600 tons per hr and will reclaim at 700 tons per hr. The yard will accommodate 350,000 tons of coal.

Occasionally coal may be stocked in other locations throughout the plant. This is done by railroad cars and grab bucket cranes.

Normal coal consumption at Aliquippa runs 8575 tons of coking coal and 1200 tons of boiler coal per day.

COKE PLANT

Metallurgical coal is removed from the bottom of the previously mentioned 500-ton surge bins through feeder gates and carried by conveyors at a rate of 750 tons per hr to two recently installed coal crushers. This new equipment, the first of its type ever utilized for this application in the steel industry, has been installed at Aliquippa Works and also at Pittsburgh Works as part of a coal beneficiation program which can produce a higher percentage of $\frac{1}{8}$-in. mesh coal for charging into the coke ovens. This will produce a stronger coke and result in improved performance for the blast furnaces.

In addition to the new crushers, the installation includes blending facilities for mixing of high and low volatile coals, and also sampling facilities. It will have a rated capacity in excess of 3,500,000 tons per year. The new equipment replaces older hammer-type crushers which are being used as blenders.

Other phases of the ultimate program will include reduction of sulphur and ash in the coal, and maintenance of bulk density by the addition of either oil or water.

Coking facilities consist of four batteries of by-product ovens arranged in a single row. No. 1, 3 and 4 batteries are of modern underjet design with ovens $15\frac{1}{4}$ to $18\frac{3}{4}$ in. wide, 40 ft-$5\frac{1}{2}$ in. long, and 13 ft high. These ovens take a normal charge of 17.25 tons of coal. No. 1 and 4 batteries each have 106 ovens, while No. 3 consists of 59 ovens.

No. 2 battery is composed of 81 ovens of gun-flue design with top crossovers, each over 15 to 17 in. wide x 40 ft-8 in. long x 14 ft high. Each of these ovens takes a normal charge of 18 tons of coal.

All batteries are underfired with coke oven gas, using 40 to 42 per cent of the gas produced. Air for combustion is heated in regenerators beneath the ovens.

This bucket conveyor unit unloads coal from river barges at a rate of 1500 tons per hour. It handles most of the coal going to the coke plant.

Normal gas pressure in the ovens during coking is 6 to 8 mm of water pressure. Flue temperatures average 2400 F, and stack temperatures about 610 F. Six 250-ft stacks serve the ovens, with drafts automatically controlled at about 23-mm of water pressure.

Each battery is served by a three-hopper larry car operating along the battery top and carrying a carefully weighed charge for one oven. Each battery also has a combination pusher-leveler-door machine on the pusher side, a door machine and guide on the coke side, and a quenching car. Automatic interlocks and signal systems insure the pushing of the proper ovens as scheduled.

Coke, at temperatures of 1800 to 1850 F, is pushed into the quenching car, taken to one of the three brick quenching towers and then dumped on one of two 240-ft coke wharves.

In quenching, about 8000 gal of water is sprayed on the coke during a period of about two minutes. Quenching is controlled automatically to insure uniform practice and uniform moisture in the coke.

After cooling on the wharf, coke is taken by belt conveyor to a screening station of 200-tons per hr capacity. Here the run-of-oven coke is separated into three sizes. All coke over 1¼ in. is furnace coke. The portion under 1¼ in. and over ¾ in. is nut coke. Anything smaller than ¾ in. is coke breeze. Furnace coke and nut coke are moved in hopper cars to the blast furnace bins, where they are stored and charged separately. Coke breeze is sent to the boiler house.

With full operations, coking time is 17 hr, giving 497 ovens pushed each day. This would require 8573 tons of coal, and produce 6000 tons of furnace and nut coke and 360 tons of coke breeze. Of this furnace coke, about 5200 tons per day are used in the Aliquippa blast furnaces and 800 tons are sent to the company's plant at Cleveland, Ohio. The coke has analyses averaging as follows:

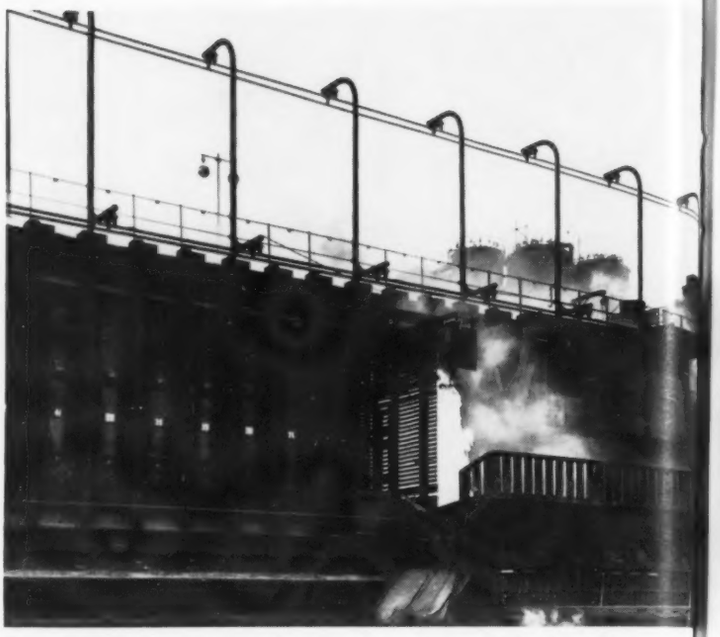
	Per cent
Volatile matter	0.73
Fixed carbon	89.64
Ash	9.63
Sulphur	1.19

Modern equipment is provided for the recovery of the usual by-products of coal carbonization. The gas coming from the ovens first passes through the primary coolers, eight in number, of shell and tube type.

Next, the gas passes through the exhausters. There are three 48,070-cfm, steam turbine driven exhausters. After the exhausters, the gas passes through four electric precipitators to remove the tar fog.

From the precipitators, the gas goes through reheaters, and thence to the saturators.

The saturators, of which there are two, (one in operation and one as a spare) are large spherical bottom and conical top tanks, 25 ft in diameter. They are made of stainless and carbon steels, with the carbon steel portion being leadlined. Each unit is rated at 90,000,000 cu ft of gas per day. About 35,000 gal of dilute sulphuric acid serves as the bath through which the gas is pumped. It is here that the ammonium sulphate is produced.



Four batteries of by-product coke ovens provide capacity for coking 8575 tons of coal per day.

After leaving the saturators, the gas goes to the final coolers, where, with countercurrent water flow, the gas is cooled. There are two final coolers, both on stream at all times. They are 17 ft in diameter, and 93 ft-6 in. high, and operate in parallel. About 200,000 gal of water per hr pass through these towers to cool the gas. This final cooler water is a closed system, with cooling towers to cool the recirculated water.

After leaving the final coolers, the gas enters the benzol washers. The scrubbing medium is a light petroleum oil which has an affinity for benzol products, and a boiling point sufficiently high to permit distillation of the lower boiling light oil products without vaporizing the petroleum oil. Wash oil, as it is called, is circulated at the rate of 66,000 gphr, and absorbs 1300 to 1400 gphr of light oil. There are four benzol washers, normally all on the line in parallel at one time. Each is 14 ft-6 in. in diameter, and 100 ft high.

In the primary coolers, as previously mentioned, ammonia liquor vapors are condensed. This, together with that which is condensed in the gas mains, amounts to 30 to 35 gal per ton of coal charged, or between 200 and 250,000 gal per day. It is necessary to recover the ammonia and phenol from this liquor.

To recover the phenol, the liquor is thoroughly mixed with 1 to 1.5 parts of light oil which absorbs the phenol from the liquor. This phenolized light oil is passed through caustic soda which absorbs the phenol from the light oil to form sodium phenolate. The light oil is then returned to the system to recover more phenol from additional liquor.

After the phenol is removed, the ammonia liquor is passed through a still where ammonia vapor is distilled off and put back into the gas as it goes to the saturator. Here it is recovered as ammonium sulphate in the usual way.

Another product of importance recovered from the primary coolers and the gas mains ahead of them is tar. This is collected in a decanter tank, where it separates by gravity from the ammonia liquor, and is pumped to

storage tanks. Tar production is 9.86 gal per ton of coal charged, or about 85,000 gal per day. This is shipped to the company's Pittsburgh Works where the light tar oils are distilled off and sold for further refining. The heavier product, after distillation, is used as fuel in the Pittsburgh Works open hearth furnaces.

Returning to the light oil system, the light oil is recovered from the wash oil. The combined oils are pumped from the washers to the benzol plant where they first pass through a vapor-to-oil heat exchanger, picking up heat from the vapors already coming off the stills. From this heat exchanger, the combined oils go to the final heaters where they are further heated with indirect steam. They next enter the wash oil still, 9 ft in diameter, with 13 bubble trays. There are two stills, handling 66,000 gphr. The light oil is vaporized in these columns, and the wash oil, having a higher boiling point, is returned to the wash oil coolers, and then to the benzol washers to recover more light oil.

The light oil vapors pass, first, to the vapor-to-oil exchangers, where they give up a portion of their heat to the incoming benzolized wash oil. A small portion of these vapors are condensed here as primary light oil, which is returned to the in-coming benzolized wash oil. The vapors pass to light oil rectifiers and condensers, where the condensate is separated into secondary light oil and intermediate light oil. The secondary light oil is pumped to the CS_2 column for CS_2 removal.

The vapor product from this still is CS_2 and related products; the bottom product is light oil to be further processed for sulphur removal and separated into individual benzol plant products: benzene toluene, xylene, crude solvent naphtha, crude residue and gasoline blending stock.

Aliquippa Works refines light oil from the Pittsburgh Works as well as that recovered at Aliquippa.

In purifying the light oil, sulphur is removed by a treatment with hydrogen under controlled pressures and temperatures in the presence of a catalyst. A subsequent treatment removes paraffins by absorption.

Coke and by-product yields average as follows:

Furnace and nut coke, per cent	69.74
Coke breeze, per cent	4.21
Gas, cu ft per ton of coal	10,265
Tar, gal per ton of coal	9.86
Light oils, gal per ton of coal	3.61
Ammonium sulphate, lb per ton of coal	19.47

Approximately 40 per cent of the gas make is used to underfire the ovens. Surplus gas to the extent of about 60 per cent of the gas make is pumped at 3 to 4-psi pressure by three 23,800-cfm turbine-driven boosters through two 30-in. gas mains which extend throughout the steel plant. An 80,000-cu ft water-sealed gas holder is provided on the gas system.

BLAST FURNACES

Five blast furnaces provide a total iron-making capacity of 2,090,000 net tons per year. These furnaces form a line near the north end of the plant, paralleling the ore yard. Table IV gives principal design and operating characteristics of the furnaces.

It might be noted from Table IV that, except for hearth and bosh diameters, the five furnaces are remarkably similar in design. Also to be noted is the use of tapered linings, which are quite thick just above the mantle and thin out up through the stack and throat. This feature is primarily the result of the enlargement of the furnaces over the years, while keeping the original shell.

It is interesting to recall that the Aliquippa plant pioneered in the use of large hearths in blast furnaces. In fact, No. 5 furnace is said to be the first in the United States to average more than 1000 tons of iron a day for an entire year. This was in 1928. Also, in March, 1943, No. 3 furnace set a record for iron production with 48,505 net tons, a daily average of 1565 tons.

All hearth cooling is done by cast iron staves 4½ in. thick x 15 ft 4½ in. long, and conventional bronze cooling plates are installed in the bosh and tuyere breast section. No cooling plates are used above the mantle. Stockline protection is provided by rolled steel Z-sections built into the brickwork.

Each furnace has four 4 ft-9 in. diam offtakes spaced equidistant around the stack, with their center-lines 5 ft-11 in. below the top of the lip ring.

Each furnace is served by motor-operated double skip hoists, with skip cars of 122-cu ft capacity. Each furnace has a rotating distributor top, and all bell hoists are steam-operated.

The five furnaces have a common underground stock-house and a ground level trestle carrying three tracks, two of which run over a double row of stock bins, while the third is for transfer car operation. No. 1 and 2 furnaces have 32 parabolic bins for ore and stone, and one large coke bin for each furnace. No. 3 and 4 furnaces are similarly arranged. No. 5 furnace has 26 bins for ore and stone, and one large bin for coke.

All limestone and miscellaneous materials are unloaded directly into the bins from hopper cars. Coke is likewise unloaded from hopper cars, and is passed over vibrating screens between the coke bins and the skip cars.

Two charging sequences are normally used: OO-SCCC/ on No. 5 furnace and OOOSCCCC on the others. Automatic charging sequence control is installed on all furnaces.

Coke is charged by volume; ore and stone by weight.

Blowing equipment for the furnaces is comprised of two turboblowers rated at 100,000-cfm, 30-psi pressure; one turboblower rated at 60,000-cfm, 30-psi; one turboblower rated at 45,000-cfm, 30-psi; and 10 double vertical blowing engines with 84 x 60-in. air tubs, each capable of delivering a maximum of 30,000 cfm.

The turboblowers operate on 400-psi steam, and are equipped with surface condensers. The blowing engines operate on 150-psi steam and have atmospheric condensers.

The two large blowers and one of the smaller turbo-blowers are usually used to blow No. 1, 2 and 3 furnaces through a split wind blowing system. The smaller unit is normally base loaded while the speeds of the large units are varied by automatic controls to meet the demands of the furnaces. No. 4 and 5 furnaces are blown by the engines.

The five blast furnaces at Aliquippa have an annual capacity of 2,090,000 tons of iron. They produce iron of basic and bessemer grades.

Four two-pass, side-combustion hot blast stoves heat the blast for each furnace. Stove details are given in Table IV. Most of the stoves have conventional basket-weave checkerwork, with a few using patented designs. Stove burners are of pressure proportioning type of 15,000-cfm capacity. The stoves normally operate six hours on gas and two hours on blast, consuming 25 to 30 per cent of the gas made by the furnaces. Stack temperature of the stoves averages about 350 F. Blast temperatures average 1075 F, but may be increased to about 1250 F at times and blast pressure, 15 to 18 psi. Blast temperatures are automatically controlled by mixer valves on all furnaces.

Top gas temperatures normally run 250 to 450 F, and top pressures 15 to 40 oz per sq in. All furnaces are equipped with conventional dust catchers 30 ft in diameter.

Gas for stove consumption only is wet-washed in three 50,000-cfm tower washers and fine-cleaned in three 40,000-cfm rotary disintegrators to 0.008 to 0.025 grains of dust per cu ft. Three 60,000-cfm eliminators following the disintegrators remove moisture. Part of the surplus gas for boilers is dry cleaned in four 95,000-cfm cyclone type vortex cleaners. A small amount of gas is wet-washed in a 10,000-cfm stationary disintegrator tower washer for use at the soaking pits.

Water from the gas washers and disintegrators flows to two thickening tanks, 105 ft in diameter, each capable of handling 8000 gpm. Sludge from these tanks is pumped to two disk type filters, dewatered, and discharged into the sintering plant bins.

Just coming into production is a new traveling grate sinter machine believed to be the largest in the world. This machine has pallets 13 ft-2 in. wide, and is 183 ft-9 in. long over the 14 divided windboxes. The total grate area of 2419 sq ft is expected to produce 6500 tons of self-fluxing sinter per day.

The sinter plant includes all facilities for receiving and screening raw materials, crushing of coke, metering of ores and miscellaneous materials, preparation of sinter mix, sintering, hot sinter screening, sinter cooling, cold sinter screening, emergency stocking of sinter and loading out of sinter product, crushed coke and coarse ore.

As the Aliquippa blast furnaces regularly produce both low manganese basic iron and bessemer iron, the plant is designed to produce both basic and bessemer sinter, alternating feed every few hours. The layout permits provision for an additional sinter machine with a minimum of changes in conveyors and handling facilities.

All of the raw materials except filter cake will be received at track hoppers which can be serviced by railroad hopper cars, ore yard transfer cars or mobile equipment. The filter cake will be delivered by conveyor from an existing sludge filter house.

The materials handling system and storage are designed to handle material for a full day's production in a single 8-hr turn.

Materials are drawn from the various bins in the desired proportions and conveyed to a 12 x 30-ft mixing drum. The mix is then put through dual 12 x 30-ft balling drums.

Providing the suction are twin induced draft fans, each with a capacity of 350,000 cfm at 350 F producing a vacuum of 35-in. water column at the fan inlet. The fan breechings exhaust to a common stack 18 ft in diameter and 140 ft high with a venturi section 40 ft from the top.

The ignition furnace consists of a welded steel shell with a rammed refractory lining. Three rows of 21 burners each are designed for firing with natural gas or coke oven gas and generate a total heat input of 150,000 Btu per ton of sinter.

Sinter cake from the machine falls onto a crash deck arranged to feed the cake to a sinter breaker. The breaker is designed to reduce the sinter product to a nominal size of 8 in. Hot screened sinter is fed to a circular sinter cooler by parallel feeders in series. The cooler has a mean tray diameter of 110 ft and a tray width of 12 ft. The 36 trays provide an effective cooling area of 3400 sq ft and the induced draft system is designed to cool 444 net tons of sinter per hour. Four centrifugal fans rated at 330,000 cfm each at a mean air temperature of 300 F and vacuum of 2.25-in. water column provide air for cooling. These fans exhaust to individual stacks 75 ft high.

Cooled sinter is fed from the cooler to a 42-in. conveyor belt, rated at 450 tons per hr, by dual vibrating feeders. Final sinter product is conveyed either to a load-out station or to an emergency swinging stacker 72 ft long for stocking directly to the ore yard.

Bessemer and low manganese basic irons are produced in approximate proportions of 40 and 60 per

TABLE IV
Blast Furnace Data

Furnace No.	1	2	3	4	5
Diameter of hearth, ft-in.	28-6	28-6	28-6	27-0	26-6
Diameter of bosh, ft-in.	30-0	30-0	30-0	29-6	28-9
Diameter of stockline, ft-in.	19-0	19-0	19-0	19-0	19-0
Height, iron notch to stockline, ft-in.	74-3	74-3	74-3	74-3	74-3
Height of crucible, ft-in.	11-0 3/4	11-0 3/4	11-0 3/4	10-6 3/4	10-6 3/4
Height of bosh, ft-in.	12-7 1/2	12-7 1/2	12-7 1/2	12-7 1/2	12-7 1/2
Height of straight section, ft-in.	5-2 1/4	5-2 1/4	5-2 1/4	5-2 1/4	5-2 1/4
Height of inwall section, ft-in.	43-0	43-0	43-0	43-0	43-0
Height stockline section to top ring, ft-in.	18-7 1/2	18-7 1/2	18-7 1/2	18-7 1/2	18-7 1/2
Height, bottom to iron notch, ft-in.	1-9	1-9	1-9	1-9	1-9
Height, iron notch to cinder notch, ft-in.	3-9	3-9	3-9	3-9	3-9
Height, cinder notch to tuyeres, ft-in.	3-3	3-0	3-3	3-3	3-3
Working volume, tuyeres to stockline, cu ft	33,700	33,700	33,700	32,575	31,520
Bosh angle, deg-min-sec	86-36-0	86-36-0	86-36-0	84-20-44	85-54-28
Inwall slope, in. per ft	1 13/16	1 13/16	1 13/16	1 3/4	1 5/8
No. of tuyeres	18	18	18	16	18
Tuyere diameter, in.	7	7	7	7	7
No. of columns	12	12	12	16	12
Lining thickness, crucible in.	45 1/4	45 1/4	45 1/4	51 1/4	45
Lining thickness, bosh in.	31 1/2	31 1/2	31 1/2	31 1/2	31 1/2
Lining thickness stack, in.	36 to 81	36 to 81	36 to 81	36 to 75	36 to 67 1/2
Lining thickness, throat, in.	13 1/2 to 34 1/2	13 1/2 to 34 1/2	13 1/2 to 34 1/2	13 1/2 to 34 1/2	13 1/2 to 34 1/2
Big bell diameter, ft-in.	14-0	14-0	14-0	14-0	14-0
Big bell angle, deg	55	55	55	55	55
No. of stoves	4	4	4	4	4
Stove diameter, ft	22	22	22	22	22
Stove height, ft	100	100	100	100	100
Checker openings, in. square	(3) 4 3/8 (1) 4 1/4	(2) 4 3/8; (1) 9 (1) 3 1/2	(3) 1 7/8 (1) 4 3/8	(3) 4 3/8 (1) 4	(4) 4 3/8 ...
Heating surface per stove, sq ft	(3) 136,000 (1) 176,400	(2) 136,000; (1) 48,300 (1) 140,000	(3) 135,200 (1) 136,000	(3) 136,000 (1) 118,500	(4) 136,000 ...
Blast volume, average, cfm	85,000	85,000	85,000	80,000	80,000
Blast volume, maximum, cfm	87,000	87,000	87,000	83,000	83,000
Daily iron production, average, net tons	1,300	1,330	1,330	1,255	1,255
Daily iron production, maximum, net tons	1,400	1,400	1,400	1,350	1,350

cent respectively. Normally, No. 1, 2 and 3 furnaces are on basic iron, No. 4 and 5 on bessemer. Iron specifications are as follows by per cent:

	Bessemer iron	*Low-manganese basic iron*
Silicon	1.10–1.40	1.10–1.40
Sulphur	0.032 max	0.035 max
Phosphorus	0.085 max	0.150 max
Manganese	0.40–0.50	0.40–0.50

Each furnace makes five casts in 24 hr into mixer type ladles of 190 tons capacity. Normally, no iron is pigged, although three double-strand pig machines of 140 tons per hr total capacity are available.

Slag from the furnaces runs about 900 lb per ton of iron, depending on furnace practice. Slag analyses average as follows:

	Per cent
SiO_2	35.43
Al_2O_3	10.47
CaO	43.71
MgO	8.03
S	1.86
Fe	0.24
Mn	0.28

All of the slag is flushed into cinder pots and moved to a slag dump north of the plant, where it is dumped and allowed to solidify and cool. Part is then processed by a commercial slag company, the balance discarded in a slag fill.

Furnace practice shows average figures about as follows:

	Lb per net ton of iron produced
Ore and sinter used	3475
Limestone	700
Coke (adjusted to 3 per cent moisture)	1600
Scrap charged	200
Roll scale charged	90
Slag produced	900
Flue dust produced	150
Furnace scrap produced	19

Surplus gas is used chiefly under boilers, with a little going to soaking pit fuel.

STEELMAKING

Four different steelmaking processes are used at Aliquippa. New facilities are two basic oxygen furnaces which, combined with three acid bessemer converters and five open hearth furnaces, provide a total capacity of 2,428,000 net tons of ingots, per year. Of this, oxygen steel accounts for 880,000 tons, bessemer steel for 384,000 tons and open hearth steel for 1,164,000 tons. The open hearth product may be made either by the duplex process or the scrap-and-iron process.

The oxygen furnace shells, 17 ft-8 in. in diameter, are made of 2-in. steel plate, with 1½ in. plate for the cone section. They are lined with burned magnesite brick against the steel plate, a rammed layer of tar-magnesia mix and an inner lining of tar-bonded magnesite or dolomite brick. Lining thickness runs 36 in. on the bottom, 26½ in. on the sidewalls and 20½ in. in the cone section. The brick is laid as an inverted arch in the dished bottom, with keyed rings in the sidewalls and cone. Lining life is currently averaging in excess of 200 heats.

The furnaces are carried by trunnions which ride in anti-friction bearings on cast steel pedestals. Each furnace is tilted by two 130-hp, d-c motors under adjustable voltage control.

A typical charge might be 130,000 lb of molten iron and 50,000 lb of steel scrap. Scrap is loaded by crane and magnet into a scrap charging car with tilting box, which dumps the scrap into the tilted furnace. Hot metal comes from the blast furnaces in 190-ton mixer-type ladles, from which the desired amount of iron is poured into a charging ladle. An overhead crane tilts this ladle over the nose of the furnace and transfers the iron. Some iron ore pellets or roll scale may then be added, as well as lime and perhaps some fluorspar.

These fluxes and other additives are unloaded from railroad cars, elevated by skip hoist and distributed by belt conveyor to overhead storage bins. The materials are withdrawn, as needed, into an overhead larry car which dumps into a chute leading to the furnace.

The furnace is then tipped upright and a water-cooled oxygen lance with a 2.05-in. diam nozzle is lowered to a predetermined position above the surface of the bath. Oxygen is turned on at about 175-psi pressure, with a flow of about 8000 cfm.

An immediate oxidation begins, silicon and manganese in the iron burning to their oxides and raising bath temperature. Carbon also burns to CO and some iron is oxidized to FeO, which diffuses through the bath. The combination of high temperature and turbulence set up by the CO results in very rapid oxidation. Progress of the blow is judged by observation and experience. The end of the process is marked by a clearly visible drop in the flame at the vessel nose. At this point, the lance is withdrawn and the furnace turned to a horizontal position to permit the skimming off of fluid slag into a slag pot below.

The furnace is then turned down in the opposite direction to pour the steel into a teeming ladle.

While the blow is in progress, the nose of the furnace is immediately below a water-cooled hood, so that all dust and gas pass up into the hood through the action of large fans. The gases are sprayed with water to remove the heavier entrained particles and to lower the temperature from around 3000 F to less than 500 F. Electrostatic precipitators then remove the fine dust, allowing clear gas to pass up the stack.

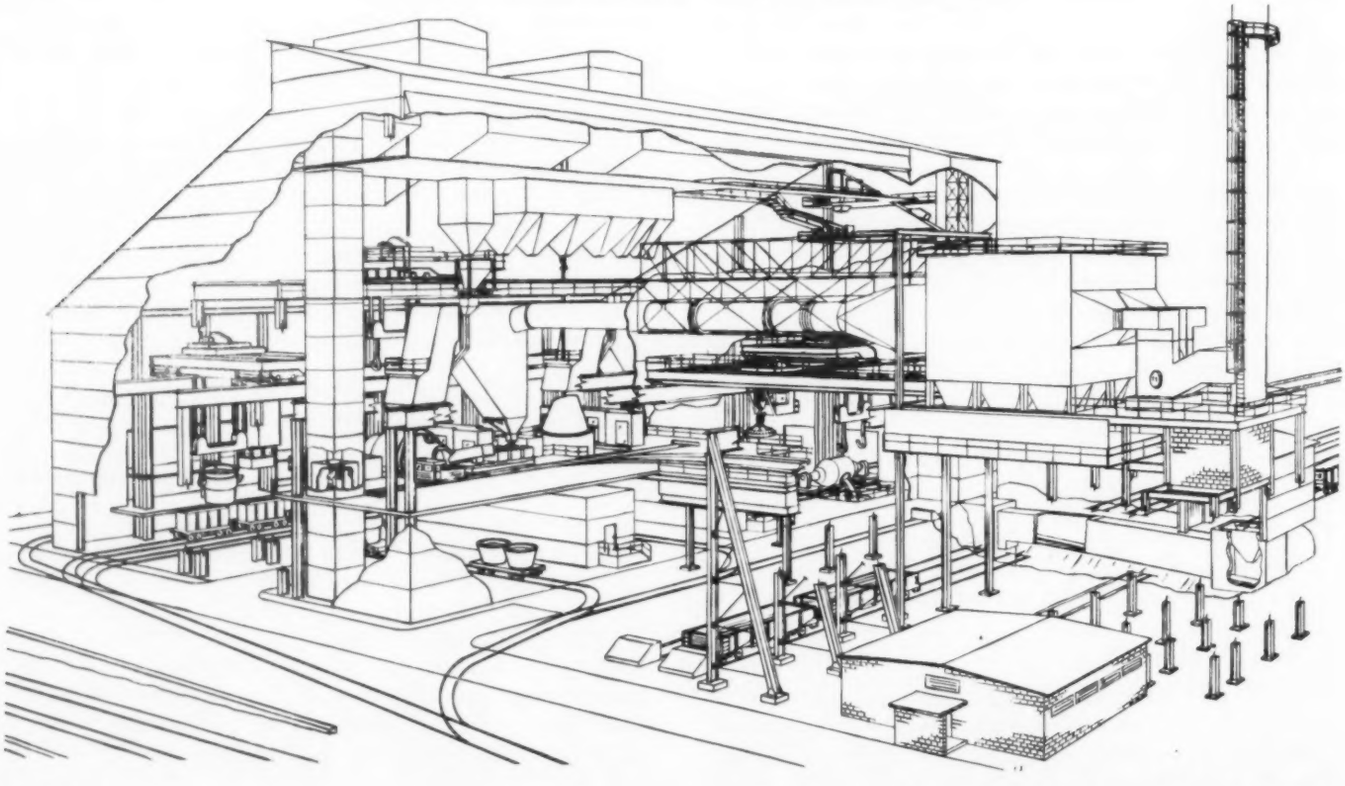
The blows usually last 20½ min, and heats run 81 to 83 tons. Tap-to-tap time averages 46.4 min. Production averages 105.5 tons per furnace hour. Oxygen consumption averages 1960 cu ft per ton of ingots.

The oxygen is purchased from the manufacturing company which designed, built and operates the oxygen plant adjoining the steel works.

The plant contains two units each capable of making 115 tons per day of 99.5 per cent oxygen, as well as streams of high purity nitrogen and argon. These units use a split cycle and are practically automatic in operation.

In order to meet the cyclic requirements of the

Cutaway perspective drawing of basic oxygen furnace shop.



process, a high pressure gaseous oxygen storage is provided which accommodates more than enough oxygen to blow a heat. Also the plant is designed so they can make a substantial portion of their production as liquid oxygen, which can be accumulated on the site in a large insulated storage system. The equivalent of 6,000,000 cu ft of gaseous oxygen can be stored here.

Iron for the oxygen process contains 1.10 to 1.40 per cent silicon, 0.35 to 0.50 per cent manganese, 0.10 to 0.15 per cent phosphorus and 0.02 to 0.03 per cent sulphur.

Analyses of the steel produced in the basic oxygen furnaces range 0.03 to 0.95 per cent in carbon, 0.20 to 1.50 per cent in manganese, with phosphorus averaging 0.012 to 0.013 per cent and sulphur 0.02 per cent. Nitrogen content averages 0.003 per cent. Alloying additions are made to the teeming ladle. Deoxidizing additions are made either to the ladle or the molds.

Flux consumption runs 130 to 140 lb of lime and about 0.9 lb of fluorspar per ingot ton. About 0.9 lb of roll scale is also used.

Steel is poured into a variety of bottle-top and open-top molds, ranging from 22 x 24 in. up to 25 x 43 in. and 27 x 37 in. The steel is applied to the production of tinplate, welded pipe, light structurals, cold heading wire and welding rods. About 72 per cent of the basic oxygen ingot production is capped and keyed, 18 per cent rimmed and 10 per cent killed steel.

Normally, the furnaces are operated one at a time, while the other is being relined. When a unit is ready for relining, it is cooled in four to six hours by air from a blower, with small amounts of water spray. The entire working lining is removed, using a pneumatic hammer on the extension arm of a piece of grading equipment. This requires 6 to 12 hr. Replacement of the working lining is done in 48 to 60 hr. Occasionally a portion of the permanent magnesite brick lining is also replaced.

The three acid bessemer converters are used to produce regular bessemer steels and to blow metal for duplexing in the open hearth furnaces.

The converter plant is housed in a building 461 x 74½ ft, served by two 75/25-ton cranes and one 50/15-ton crane. The three converters are rated as 25-ton units. Their shells are 23 ft-6 in. high and 12 ft-9 in. in diameter. Each vessel bottom contains 35 tuyeres, each tuyere having seven ⅝-in. diam holes. Two are tilted by hydraulic power, one by electric motor. Blast is supplied to the vessels by one 45,000-cfm tubo-blower and one 30,000-cfm blowing engine exhausting into a common header.

Each converter takes a maximum charge of 62,000 lb of molten iron to turn out 54,000 lb of product. Iron comes from the blast furnaces in 190-ton mixer type ladles, from which a sufficient quantity is poured into a transfer ladle to charge one converter. This ladle is hoisted by crane and emptied into a tilted converter. The blast is turned on and the converter raised to an upright position. Up to 9000 lb of scrap, which acts as a coolant, may also be charged, depending on the silicon content of the iron and other factors.

As the blow progresses, the metalloids are oxidized—first silicon, then manganese and carbon. The early portion of the blow is characterized by a short flame and heavy fumes, and as greater amounts of carbon oxidize to CO, the flame lengthens and becomes more luminous as the CO changes to CO_2. The end of the blow is indicated by a momentary halt in the flame drop, called the end point. The vessel is then turned down to avoid excessive oxidation of the iron.

Blast to the vessel is generally about 30,000 cfm, at approximately 25-psi pressure, and the blowing time normally ranges 9 to 14 min, depending on blast volume and silicon content of the iron. The photo-electric cell method of bessemer flame control, as developed by J&L, is used on all blows.

After the heat is turned down, the blown metal is poured into a bessemer teeming ladle or into an open hearth charging ladle, depending on the product. The slag remaining in the converter is then dumped into a cinder pan beneath the vessel.

Two types of iron are used in the converters. (See "Blast Furnace" section for analyses.) For the production of bessemer ingots, bessemer grade iron is used, while the low-manganese basic iron is used for the production of blown metal for the open hearths.

The blown metals poured from the converters show percentage analyses as follows:

	Bessemer metal	*Basic blown metal*
Carbon	0.03–0.04	0.04–0.50
Manganese	0.03–0.04	0.03–0.04
Silicon	0.01 or less	0.01 or less
Phosphorus	0.065–0.075	0.12–0.18
Sulphur	0.04 max	0.04 max

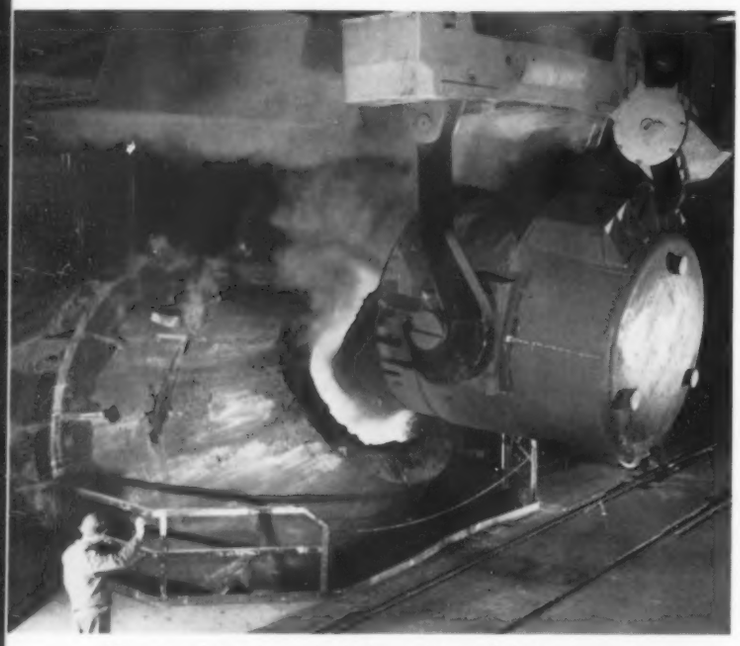
The phosphorus and sulphur contents of these metals are about the same as in the original iron, since neither are removed in the acid bessemer process. Converter slag analyses run about as follows:

	Per cent
FeO	15–20
SiO_2	55–65
MnO	8–12
CaO	0.5
MgO	0.2
Al_2O_3	5.0
TiO_2	3.0

Ferro-alloy additions to bring bessemer heats to the desired final analysis are made either to the converter during the blow or to the ladle before pouring. Ferro-phosphorus, copper and sulphur are added during the blow, while the oxidizable elements, such as manganese, aluminum, silicon, and carbon, are added in the ladle.

Bessemer heats are transferred by motor-driven transfer buggies from the converter building to the teeming building, where the ladles are handled by a 50-ton crane for teeming. The pouring platform is equipped for producing leaded steel, having a 12,000-lb lead dust storage hopper, a 1200-lb lead feeding tank, a remotely controlled lead feeder, a lead addition gun, a fume collecting buggy and, in an adjacent area, a bag filter installation for fume cleaning.

Bessemer steel production has been averaging about 27,000 net tons per month, of which about 82 per cent



Here molten iron is being charged into a basic oxygen steel converter. A typical charge might be 130,000 lb of iron and 50,000 lb of steel scrap.

is capped and keyed, 15 per cent hot-topped, and 3 per cent rimmed.

In addition, about 67,000 tons of blown metal is produced per month for the open hearth. This is transferred to the open hearth in 25-ton ladles mounted on buggies which are moved by a diesel-electric hot-metal engine.

Since converter shells must be relined every 400 to 700 heats, and heats are turned out rapidly, maintenance is a rather steady operation. The vessel to be relined is moved from its operating pedestal and placed in a relining stand. The old lining may be completely torn out, or only the shoulder and nose portions may be removed. The new lining, which consists of mica schist stone and a mortar of ganister mud, is dried with a fuel oil flame. Full linings require 12 to 14 hr drying time, patch linings 6 to 8 hr. Three spare shells permit continuous operation while maintenance is carried on.

The life of converter bottoms usually runs 45 to 50 heats, although some run higher. In one case, 101 heats were blown on a single bottom, which is believed to be a world record. After a bottom has been put into service, the wind box cover is removed once or twice each 8-hr turn to inspect the tuyeres that have burned out are blanked off.

When the length of the tuyeres decreases from the original 34 to 16 in. or less, or when the bottom leaks and cannot be repaired, the bottom is replaced, the change requiring one to two hours. Jack cars remove the old bottom, transport it to the bottom house, and force the new bottom into place on the converter.

In the bottom house are storage bins for the various stones and clays used in converter and ladle maintenance. Two mud pans prepare the necessary mixes and mortars. The old material is removed from the bottom shell and the 35 new tuyeres are inserted. A mud mix is then poured in and about 80 bottom tile placed between the tuyeres. The reconstructed bottom is then placed in one of eight gas-fired ovens and dried at 400 to 500 F for a minimum of 48 hr. New bottoms are available at all times to be placed into service as needed.

Open hearth steel is produced by the duplex process, by the scrap and hot metal process or by a combination of the two. The original installation in 1912 consisted of four tilting furnaces, which are particularly adapted to the duplex process. In 1937 one additional furnace of stationary design was built. This furnace uses the scrap and hot metal process exclusively.

The four 150-ton tilting furnaces, built on 110-ft centers, are 90 ft long inside the buckstays x 22 ft wide. Bath dimensions at the foreplate level are 44 to 50 ft long x 18 ft-7½ in. wide, giving hearth areas of 704 to 784 sq ft. The 150-ton stationary furnace is 70 ft-6 in. long x 23 ft wide, with a bath 42 ft long x 20 ft wide, giving 728 sq ft area.

Furnace bottoms are about 36 in. thick, built up of 4 in. of insulating material and 14 in. of brick, variously topped with burned magnesite or a ramming mix and burned magnesite.

Furnace roofs are 15 in. thick with 18-in. ribs. Zebra courses of basic brick are used along the back skewbacks. Basic brick front walls are used in all furnaces, and basic brick panels are installed in the port ends. The stationary furnace has suspended basic ends.

The tilting furnaces are supported on rockers and are tilted on rollers by motor-operated screw mechanisms. Double slag pockets are incorporated in the tilting furnaces, single pockets in the stationary furnace.

All furnaces have double regenerator chambers at each end. The smaller chamber is 7 ft-9½ in. wide, the larger, 12 ft-10 in. wide. Both are 21 ft long, and contain checkerwork 10 ft-6 in. to 15 ft deep.

Oil is the principal fuel, but the two end furnaces also use some coke oven gas and natural gas. For the entire shop, fuel consists of about 80 per cent oil, 20 per cent gas.

Fuel oil is received chiefly by river barge, but truck and tank car shipments can also be handled. As received, it is pumped into two 2,300,000-gal storage tanks which are protected by foamite systems.

From the storage tanks fuel oil is pumped through a circulating system at 175-psi pressure, 135 to 140 F temperature. At each furnace, an individual heater raises oil temperature to about 190 F. Water-cooled artillery type burners are used, with single barreled units on the three oil-burning furnaces and double-barreled burners on the furnaces which use oil and gas.

All of the furnaces have automatic reversal equipment, based on temperature differential. Also, all furnaces have roof temperature recorders, oil meters, fuel-air ratio controls, damper controls, and radiation pyrometers for bath temperature. Four of the furnaces are equipped with 28,000-cfm forced draft fans.

Typical experience will find the open hearth turning out about 98,000 net tons of ingots per month of which about 73 per cent will be by duplex process, 18 per cent by scrap and hot metal, and 9 by the mixed process (a combination of the other two).

For duplexing, the furnace charge consists of burned lime, limestone, roll scale, blown metal and molten iron. About 85 per cent of the charge is blown metal

and 13 per cent hot iron. For scrap and hot metal heats, a charge of limestone, 60 per cent scrap and 40 per cent hot metal is used. In mixed practice, the charge is a mixture of scrap, blown metal and hot iron, preceded by a flux. In a month of full production the open-hearth will use about 22,000 tons of molten iron direct from the blast furnaces, 68,000 tons of blown metal from the converters and 12,000 tons of scrap.

Heats of 152 tons are tapped, with heat times averaging 3 hr 48 min for the duplex process and 9 hr 56 min for the scrap-hot metal process. Production rates are 40 and 15.54 tons per furnace-hour, respectively, for the two processes, and fuel consumption 1,650,000 and 4,029,000 Btu per ton of steel produced.

An unusually wide variety of types and grades of steel is made, as evidenced by typical performance records showing 53 per cent of the production as killed steel, 13 per cent as fine grain steel, 13 per cent rimmed and 21 per cent capped and keyed. To further complicate the picture open hearth steel is produced in analyses showing the following ranges:

	Per cent
Carbon	0.05–1.05
Manganese	0.18–2.65
Phosphorus	Up to 0.15
Sulphur	Up to 0.33
Silicon	Up to 0.35
Chromium	0.60–0.80
Molybdenum	Up to 0.35
Vanadium	0.05–0.20
Copper	Up to 0.35
Aluminum	Up to 0.05
Nitrogen	Up to 0.015
Boron	0.002–0.003
Zirconium	0.10–0.20
Titanium	0 01–0.05
Lead	0.15–0.35

The oxygen blow lasts about 20.5 min. During the blow, a water-cooled hood collects dust and gases, which are then cooled and passed through a precipitator.

The production of these various grades of steel requires the use of fluxes, deoxidizers and alloys averaging overall, as follows:

	Lb per ton
Burned lime	59.17
Limestone	43.93
Fluorspar	2.88
Roll scale	54.35
Ferro-silicon	2.98
Speigel	4.13
Si-Ti-Al alloy	1.54
Ferro-manganese	19.03
Aluminum	0.67

Smaller amounts of molybdic oxide, copper, ferro-phosphorus, sulphur, ferro-vanadium, lead dust, etc., are also used.

Eight principal mold types are used:

- 22 x 24 in., 25 x 27 in., and 25 x 43 in. bottle tops, for capped and keyed, and silicon capped ingots.
- 24 x 24 in. open top or hot top, for rimmed, semi-killed, killed and fine grain steel.
- 25 x 43 in., and 24 x 48 in. open top, for rimmed and semi-killed steel.
- 24½ x 24½ in. big-end-up, for killed and fine grain steel.

Molds are prepared for teeming by cooling them in water and spraying with powdered pitch and a commercial preparation. This is done in a building 440 x 93 ft-4 in., served by two 25-ton cranes. This building also has facilities for reconditioning and preparing hot tops.

On the tilting furnaces, slag is flushed from the front of the furnaces into cinder pots during the working of the heat, and some slag is flushed from the tapping spout while tapping the heat.

On the stationary furnace, all slag is removed at the back of the furnace during the tap.

Typical percentage slag analyses are as follows:

	Duplex practice	*Scrap-hot metal process*
FeO	19.48	15.27
Fe_2O_3	7.14	6.23
SiO	10.70	15.22
CaO	45.98	46.80
P_2O_5	4.40	1.95
MnO	2.98	5.20
V ratio	3.81	2.92

Cinder pots are transferred to a slag dock and dumped there. The slag is crushed by a skullcracker, loaded into dump cars and taken to a slag disposal plant nearby.

Two carbometer stations and a chemical control laboratory on the open hearth floor make preliminary tests on all heats.

The open hearth building is 651 ft-8 in. long x 74 ft-9 in. wide, and is served by three 50/15-ton cranes and three 10-ton charging machines. The pouring bay, of the same length but 47 ft-3 in. wide, is served by three 185/25-ton ladle cranes, and contains two pouring platforms. One platform is equipped for the production of leaded steel.

More than 70 per cent of the material from the conventional bessemer converters is now duplexed in the open hearth furnaces.

Facilities for lining open hearth ladles and for making stopper rods are conveniently located here.

Adjacent to the open hearth floor is a stockhouse 330 ft long x 73 ft-2½ in. wide, containing storage bins for limestone, burned lime, roll scale, dolomite, fluorspar, iron ore, etc. The lower level of this building has storage bays for ferroalloys, ladle brick, etc.

Due to the nature of steelmaking processes at Aliquippa, the plant actually uses less scrap than is made in the mills. Consequently, little storage space is provided for scrap. Some scrap is shipped to the company's other plants.

There are two stripper yards, one with two 150-ton cranes, the other with a 200-ton stripper crane. These yards handle all ingots from the three steelmaking shops.

BLOOMING MILL

From the strippers, drags of ingots are moved to the soaking pits which are located in a building 518 ft-3 in. long, served by three pit cranes of 68-ft span. There are eleven rows of pits, providing a total of 39 holes with 4937 sq ft of hearth area. Of these, 18 pits, arranged in six rows of three, are 23 ft long x 8 ft-6 in. wide x 12 ft-6 in. deep. Five pits in another row are 18 ft-2 in. long x 6 ft-10 in. wide x 11 ft-6 in. deep. The foregoing are all of recuperative design.

There are also four rows of regenerative pits, each of four holes. One row has pits 10 ft-6 in. long x 5 ft-7½ in. wide x 9 ft deep. The other three rows are 8 ft long x 5 ft-7½ in. wide x 9 ft deep.

Coke oven gas can be used in all pits. In addition, one row of recuperative pits can use blast furnace gas and the other six rows of recuperative pits can use a mixture of natural gas and air. Pit covers are operated either by hydraulic rams or by motor-driven pinion and rack.

Normally, ingots are charged into the pits at temperature ranging 1600 to 1800 F after about two hours track time. Heating time runs approximately five hours. Fuel consumption averages 700,000 Btu per ton.

An ingot ready for rolling is drawn by pit crane and placed in an ingot buggy which carries it to the mill table at speeds up to 1700 fpm. The approach table is 45 ft long and contains a scale which records ingot weight.

The blooming mill and its drive were installed in 1953, replacing a steam-engine driven mill that set many production records during its time. The changeover was accomplished in the remarkable time of 7-days and 14½ hr downtime.

The new mill is a 44-in., two-high reversing unit, with cast alloy steel rolls of 43-in. collar diameter and 90½-in. body length running in babbitted bearings. The rolls carry passes of 8 and 12 in., and a 57$\frac{9}{64}$-in. bullhead. The top roll is hydraulically balanced and is moved up and down by 12-in. mill screws of 2-in. pitch, single thread. The screwdown mechanism is driven by two 150-hp, 400 to 1200-rpm, mill type motors, operating under adjustable voltage control. Roll lift speed ranges up to 50 fpm, and maximum opening is 44½ in.

The mill is driven by four 3000-hp, 700 to 140-rpm, 750-volt, d-c, double-armature motors, arranged in tandem twin drive. Two motors drive each roll through a 21-in. diam spindle 19 ft-7 in. long. The drive has a rated full-load torque of 2,020,000 ft-lb at 80 rpm.

Main drive motors draw power from a motor-generator set consisting of four 3000-kw, 750-volt, d-c generators, a 15 ft-10 in. diam, 220,000-lb steel plate flywheel, and a 9000-hp, 6600-volt, 360-rpm induction motor. The flywheel has 250,000 hp-sec stored energy at 360 rpm. Normally, two generators and two drive motors are connected in parallel on a separate bus, but if one generator is out of service, the remaining three generators are connected on a common bus to serve all four drive motors.

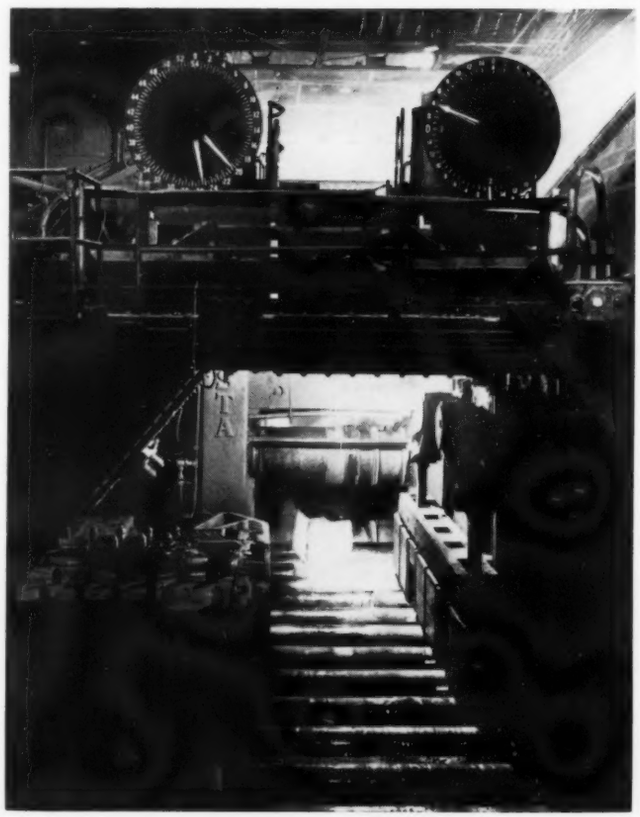
Rotating regulators are used to divide the load equally between the four drive motors. The regulating system of the drive affords rapid mill reversal—slightly less than one second from 70 rpm in one direction to 70 rpm in the other direction, and about 2½ seconds from 125 rpm to 125 rpm.

Adjustable voltage auxiliary drives draw power from special motor-generator sets, with a 300-kw, 250/500-volt generator for each mill table section, a 40-kw, 165/330-volt generator for each of the feed rollers, and two 150-kw, 250/600-volt generators for the screwdown motors.

Power consumption for the main drive and auxiliaries averages 14.5 kwhr per net ton of product.

Main drive motors, motor-generator sets, controls and switchgear are housed in a motor-room, 191 ft-6 in. x 68 ft-6 in., provided with a down-draft recirculating ventilating system. Recirculated air is passed through metallic ribbon type filters and surface type coolers. Make-up air is washed, filtered and put through an electrostatic precipitator.

The 44-in. blooming mill is driven by four 3000-hp motors in a tandem twin drive. It has set a day's record of over 7000 tons.



In the mill, the ingot is handled by overhead manipulators actuated by a 600-psi water system composed of three turbine-driven pumps and a weighted cylindrical accumulator. Sideguards are driven by two 16-in. cylinders at speeds up to 138 fpm. Hydraulic-powered fingers on the delivery side of the mill turn the ingot as desired.

Mill tables on both sides of the mill are 47 ft-3 in. long, and are each driven by two 125-hp mill type motors. Two feed rollers on each side of the mill are individually driven by 75-hp motors. All of these drives operate under adjustable voltage control, and table speeds up to 665 fpm are available.

The entire mill is lubricated by three automatic grease systems which serve 152 points; one circulating oil system of 15-gpm, 300-gal storage capacity, servicing 12 points on the screwdown; one circulating oil system of 200-gal storage capacity, serving the mill drive motors and motor-generator set; and two 300-gal oil bath systems serving the mill tables. Numerous points also require manual lubrication.

Scale falling through the tables is moved by vibrating chutes into a pit box which is emptied by crane into a hopper car.

The blooming mill is designed to roll square blooms ranging from 6 to 12⅝ in., and slabs 7⅝ to 42 in. wide x 5 to 9 in. thick. Blooms and slabs weigh from 9000 to 20,000 lb.

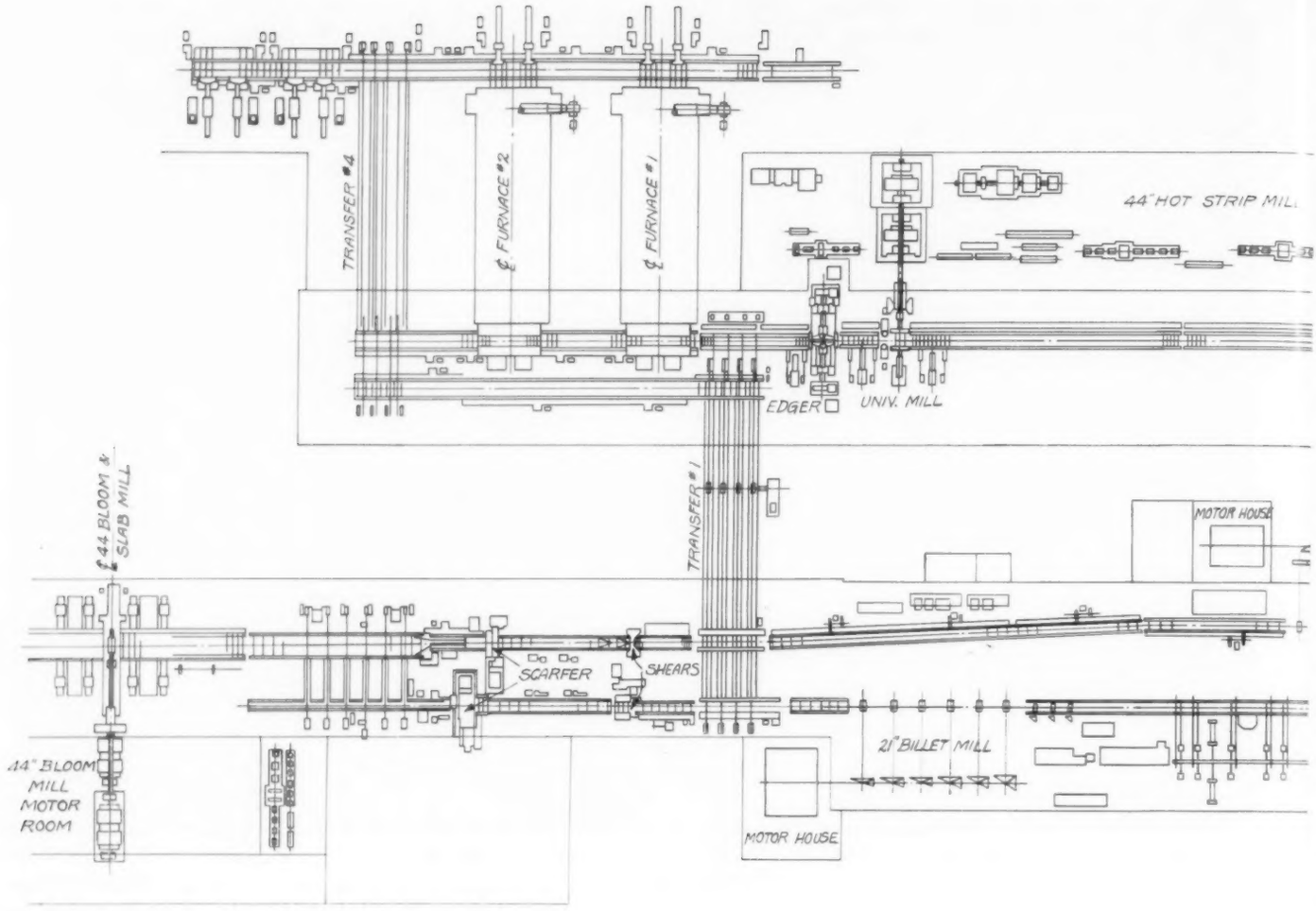
The mill rolls at speeds up to 1350 fpm, and averages about 262.8 net tons per hr. The mill has rolled as much as 494 tons per hr, 2722 tons per 8-hr turn, 7002 tons per day and 176,476 tons of blooming mill product per month.

Steel leaving the mill may follow one of three paths. Blooms to be further rolled into billets are moved from the bloomer line over a 23 ft-9 in. transfer to a parallel mill line to the right of the bloomer. They are then carried by roller tables through a flame scarfing machine to a motor-driven shear designed to cut a 64-in. section and then on to the first stand of the 21-in. billet mill, about 93 ft beyond the shear.

Blooms to be rolled down into slab billets or skelp on the 21/18-in. bar and skelp mill proceed from the bloomer straight ahead through another flame scarfer to a 600-ton hydraulic slab shear and straight on to the first stand of the 21-in. mill, some 270 ft from the slab shear. The slab shear is located 212 ft from the blooming mill and is capable of cutting sections up to 350 sq in.

Slabs from the blooming mill move straight ahead through the flame scarfer and shear, then to the left over a transfer system which carries them into the adjacent hot strip building and on through to the slab cooling and storage areas. This transfer system is connected to both runout lines of the bloomer and to the hot strip furnace discharge and charging tables. Thus, it is possible to roll hot slabs on the strip mill direct from the bloomer, with or without reheating, but the latter practice is seldom used.

Crop ends from both blooming mill shears fall through chutes into a common scrap box placed on a buggy at the bottom of a ramp. This buggy is pulled up the



ramp by cable and winch, and the scrap is dumped by crane. After cooling, the crops are loaded into gondola cars by magnet and crane.

BAR AND BILLET MILLS

The 21/18-in. bar and skelp mill is a two-high continuous mill with a roughing train of four 21-in. stands and two 18-in. stands, and, following a looping pit, a finishing train of six 18-in. stands and two vertical edgers. All horizontal stands use adjustable side-guard entry guides, and top and bottom stripper type delivery guides.

Each train is driven through gearing and pinions by a 5750-hp, 92.5-rpm, 6900-volt, 25-cycle induction motor. Stand spacing and speeds are as shown in Table V. The mill has a maximum delivery speed of 585 fpm.

This mill takes blooms, direct from the blooming mill, ranging $7\frac{5}{8}$ to 15 in. wide x 4 to $8\frac{1}{4}$ in. thick, and reduces them to slab billets $7\frac{1}{4}$ to 15 in. wide x $1\frac{7}{8}$ to $4\frac{3}{4}$ in. thick, or to skelp of $9\frac{1}{4}$ to $15\frac{3}{8}$ width and 0.196 to 0.304 in. thickness. These products are finished out of various stands of the mill, as best fits the rolling schedule. Products go principally to the 14-in. merchant mill or to direct shipment.

This mill has a rated capacity of 40,000 tons per month, but it is rarely operated at capacity. Its production depends on the distribution of steel from the blooming mill.

Skelp is cut to length by a steam-driven flying shear located 22 ft beyond the mill and capable of cutting up to 16-sq in. sections. Slab billets are cut to length on an up-cut shear of 72-sq in. capacity, placed 83 ft beyond the mill.

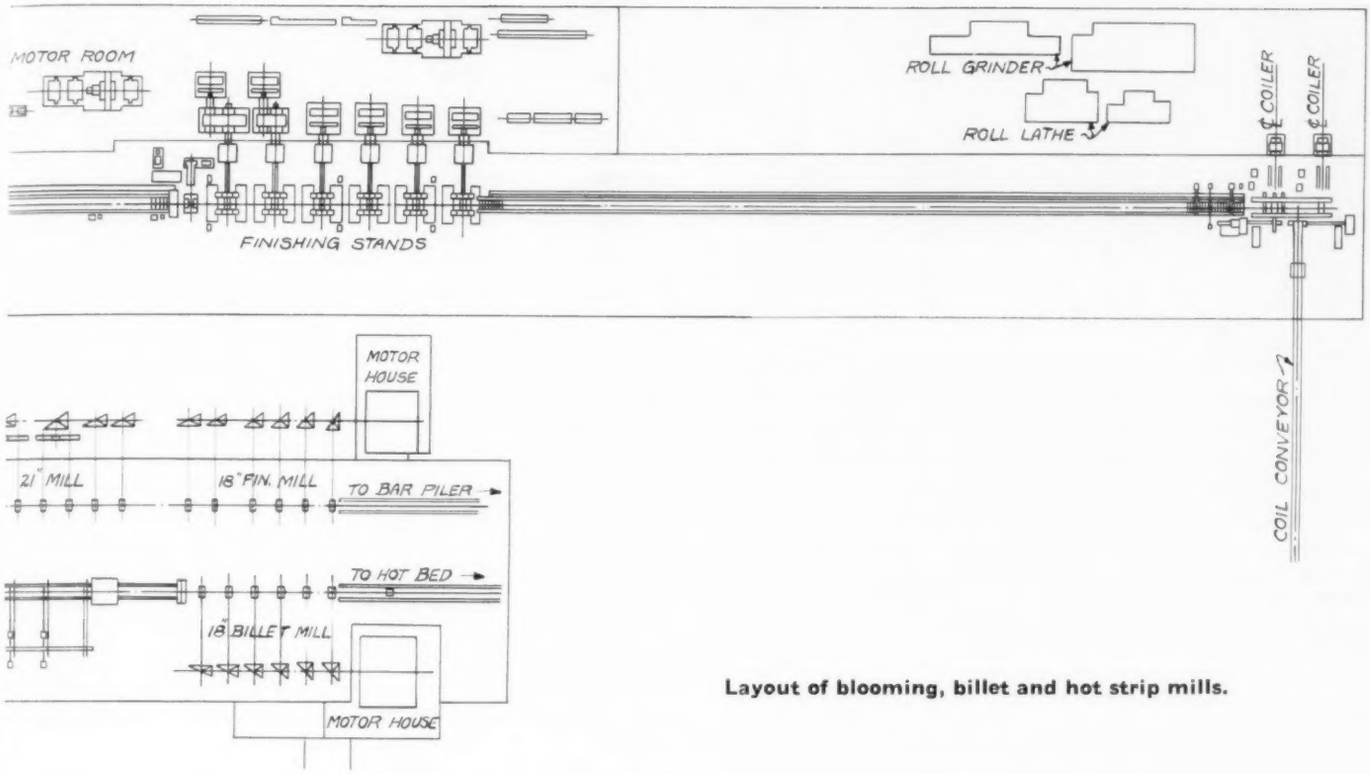
Sheared product is carried on the runout table to a hydraulic bar piler located in one of two billet yards. Piled product is carried by spider hook and crane to one of three cooling beds. After cooling, product is loaded into railroad cars for shipment or moved to a conditioning area in the billet yard.

The billet mill, which parallels the bar-skelp mill at a distance of about 35 ft, is also a two-high continuous unit consisting of six 21-in. roughing stands and, about 200 ft away, six 18-in. finishing stands preceded by a vertical edger.

Each train is driven through gearing and pinions by a 5750-hp, 92.5-rpm motor duplicating those on the bar-skelp mill. The finishing train motor also drives a crop shear preceding the train, as well as the vertical edger. Mill speeds, and stand spacing are given in Table V. The mill has a maximum delivery speed of about 575 fpm.

The billet mill receives $7\frac{5}{8}$ to $8\frac{1}{4}$-in. square blooms from the 44-in. mill, and reduces them to billets ranging from $1\frac{3}{4}$ in. squares up to $6\frac{1}{4}$ x $6\frac{1}{4}$ in. Billets smaller than 4 in. square are finished in the 18-in. train and sheared to length on a steam-operated flying shear. Billets 4-in. square or larger are finished in the 21-in. train, sheared on a 42-sq in. capacity up-cut shear, and dummied through the 18-in. train.

Roughing stands of the billet mill use box pass alloy steel rolls, running in babbitted bearings. Entry guides



Layout of blooming, billet and hot strip mills.

are of adjustable side guard type. Stands No. 1, 3 and 5 have roller twist delivery guides which twist the product 90 degrees, while stands No. 2, 4 and 6 use top and bottom box type delivery guides.

Billets to be finished on the 18-in. mill are cropped and then moved backward on the skew runout table, dropping into roller grooves for entry into the finishing stands in diamond position. The 18-in. stands use diamond and square passes in grain alloy iron rolls running in composition bearings. The guide setup on the 18-in. stands is similar to that of the 21-in. train, with roller twist delivery guides on stands No. 1, 3 and 5.

Finished billets are conveyed by roller table to one of three hot beds, where they are hand-stamped for identification and pushed off into cradles for loading by crane into rack type cars.

The billet mill has a rated capacity of 80,000 net tons per month.

MERCHANT MILL

The Aliquippa 14-in. merchant mill was erected in 1924 to the company's own design, primarily to produce junior beams but also capable of rolling angles, channels, flats, etc.

Billets 21 ft to 29 ft-6 in. long are heated in a continuous side-charged, side-discharged furnace with a hearth 32 ft wide x 52 ft long. Two furnace skid tables serving the furnace extend into two adjacent billet yards, 277 x 78 ft and 225 x 84 ft respectively. A conveyor moves billets to the furnace.

TABLE V
Bar-Skelp and Billet Mills

Stand	Roll size, in.		Distance from preceding stand, ft-in.	Roll rpm
	Maximum diameter	Body		
21—18-in. Bar and Skelp mill				
No. 1	18 1/2	25	...	9.16
No. 2	19 5/8	25	10-3 5/16	11.0
No. 3	20 5/8	25	9-3	12.52
No. 4	20 11/16	25	10-3 1/8	16.49
No. 5	17 3/16	20	10-2 11/16	23.9
No. 6	17 1/16	20	10-0	31.2
Edger	11	..	20-9.21	38.58
No. 7	17 11/16	20	4-8.79	36.04
No. 8	18 1/2	20	10-0	44.8
Edger	12 1/4	..	4-8.285	73.32
No. 9	17 15/16	20	10-3.715	61.66
No. 10	18 13/16	20	10-0	76.49
No. 11	18 1/8	20	10-0	102.34
No. 12	18 1/8	20	10-0	123.34
21—18-in. Billet mill				
No. 1	21 1/2	48	...	15.081
No. 2	21 5/16	48	12-7	18.074
No. 3	21 1/8	48	12-0	20.676
No. 4	21 3/8	48	12-0	27.407
No. 5	21 1/2	48	12-0	32.435
No. 6	21 1/2	48	11-0	43.082
Edger	12 1/2	..	195-3.21	38.576
No. 1	19	27	4-8.79	36.039
No. 2	19 3/4	27	10-0	44.804
No. 3	19	27	10-0	61.666
No. 4	20	27	10-0	76.490
No. 5	19 1/8	27	10-0	102.340
No. 6	20	27	10-0	123.333

TABLE VI
14-In. Merchant Mill

Stand	Roll size, in.		Distance from preceding stand, ft-in.	Motor hp	Motor rpm	Gear ratio	Roll rpm
	Maximum diameter	Body length					
No. 1	15½ to 20	30	...	3000	200/360	7.72	25.9/46.7
No. 2	15½ to 20	30	5-11.737			5.78	34.6/62.3
No. 3	15½ to 20	30	5-11.366			4.0	50/90
No. 4 (Edger)	16 to 19	22	11-0¾	750	360/860	7.23	9.7/118.8
No. 5	14 to 16¾	20 to 30	15-0	1700	90/205	Direct	90/205
No. 6	14 to 16¾	20 to 30	16-6	1700	90/205	Direct	90/205
No. 7	14 to 16¾	20 to 30	16-0	2100	150/460	Direct	150/460
No. 8 (Edger)	16 to 19	22	11-0	200	360/860	2.55	140.8/336.5
No. 9	14 to 16¾	20 to 30	15-0	2100	150/460	Direct	150/460
No. 10 (Edger)	16 to 19	22	11-0	200	360/860	2.55	140.8/336.5
No. 11	14 to 16¾	20	15-0	2000	210/680	Direct	210/680
No. 12	14 to 16¾	20	15-0	2000	260/800	Direct	260.88
No. 13	29 to 33	17	8-7.408			3.97	65.5/201.6

This furnace is fired with coke oven gas, and is equipped with automatic controls on fuel-air ratio and furnace pressure. It consumes 1,900,000 Btu per ton of steel.

As the heated billet is removed from the furnace by pushout ram and ejector pinch rolls, it passes through a shear where it may be cropped or divided as desired.

The mill is a straight-away continuous mill of 12 stands, with a 13th stand replacing No. 12 when junior beams are being rolled. The first three stands, which are driven through gearing by one motor, are 16-in. roughers. Stands No. 4, 8 and 10 are bottom-driven vertical edges. The remaining stands, individually driven, are 14-in. units, but in some cases, 16-in. pinions and larger rolls are used on No. 9 and 12 stands. It is planned to change to 18-in. pinions on the first three stands and 16-in. pinions on the other stands in the future, as this mill is called on to roll some oversize sections.

When rolling junior beams, No. 12 stand is removed and another stand, No. 13, is put in. This stand has 29-in. pinions and large horizontal rolls, driven through gears by the regular No. 12 drive, and also 18-in. vertical idler rolls.

The mill has a maximum delivery speed of 3300 fpm out of No. 12 stand, quite fast for a mill of this type at the time of its construction. When No. 13 stand is used, a maximum delivery speed of 1670 fpm is available.

Material leaving the mill is delivered over a 300-ft runout table containing 64 individually driven rollers, and is kicked off on to a 250 ft-6 in. walking beam hot bed. Next, all product except flats over 6 in. wide are straightened by two roller units in the hot bed runout.

Straightened product is accumulated for multiple shearing or sawing on two combination units. Sheared product is moved to a bar piler which deposits the piles on skids for overhead crane handling to a scale and to storage. Overhead cranes also load products into railroad cars or trucks for shipment.

The main mill building, which houses the furnace, roll train, hot bed, straighteners and other auxiliary equipment is 894 ft-8 in. long x 100 ft-4 in. wide, and is served by two 20/5-ton cranes and one 10-ton crane. The mill also uses 20,000 sq ft of space in another building for slitting junior beams into tee-bars and for reshearing and straightening rim sections.

Table VI gives data on the mill layout and speeds. It should be mentioned that the roll diameters given in this table are typical for flat products and may be somewhat different for other types of product.

The first two horizontal stands and all three edgers have babbitted bearings, while all other stands use composition bearings. Roller bearings have been applied in the mill drives. All stands are provided with motor-operated screwdowns.

Scale is removed from the steel by hydraulic sprays at No. 1, 2 and 3 stands. Water at 1000-psi pressure is supplied by a motor-driven 1000-gpm centrifugal pump.

The 14-in. mill takes billets $2\frac{1}{32}$ to 15 in. in width and $2\frac{1}{32}$ to 4 in. in thickness. It rolls 6, 7, 8, 10 and 12-in. junior beams, 10 and 12-in. junior channels, 10 and 12-in. joist beams, 14-in. light beams, and 3, 4, 5, 6 and 8-in. standard channels. Flat rolled material is produced ranging $1\frac{1}{2}$ to 15 in. wide and $\frac{3}{16}$ to 2 in. thick, with the limitations of thickness being not greater than half of the width and in the lighter gages of $\frac{3}{16}$ to $\frac{5}{16}$ in., the minimum width is 2 in. Angles are rolled in open passes in sizes of $1\frac{1}{2}$ to 6 in. in equal leg sections and from 2 x $1\frac{1}{4}$ in. up to 6 x 4 in. in unequal leg sections. Some special sections are also rolled, including rim sections and cutter bar.

The foregoing sections are produced regularly in standard gages. In addition, many special sections, such as junior beams, hinge sections, rim sections, etc., are made on this mill. Because most of the sections rolled on this mill are made in open passes, guides are very important and must be designed for quick, accurate adjustment and rigid stability.

Rolling rates average 40 tons per hr, with records of 735 tons in an 8-hr turn and 31,978 tons in one month.

10-IN. SKELP MILL

Skelp for the production of welded pipe comes from the 18-in. mill previously described, and from a 10-in. skelp mill, designed to roll billets ranging $2\frac{5}{16}$ to $7\frac{7}{8}$ in. in width and $2\frac{1}{4}$ to $2\frac{5}{16}$ in. in thickness into skelp $2\frac{5}{8}$ to $7\frac{3}{4}$ in. wide and 0.10 to 0.25-in. thick. The 10-in. mill also produces some strip.

This unit is installed near the billet yards serving the two 18-in. mills, and its furnace charging skids extend into the billet yards. Thus, steel rolled on either of the

TABLE VII
10-In. Skelp Mill

Stand	Roll size, in.		Distance from preceding stand, ft-in.	Motor hp	Motor rpm	Gear ratio	Roll rpm
	Maximum diameter	Body length					
No. 1	10 3/8	15	...			3.77	17.3/30.6
No. 3	11 3/8	15	6-3.446			2.69	24.2/43.0
No. 4	9 3/8	15	4-3.682	1300/2000	65/115.4	1.525	42.6/76
No. 5 (Edger)	11 3/8	4 1/4	3-11.989			1.605	40.5/72
No. 6	9 3/4	15	4-0.733			1.0	65/115.4
No. 7	10	15	8-10.359			0.685	95.1/169
No. 8 (Edger)	11 5/8	4 1/4	18-1 41/64	167	251/450	3.04	82.5/147.5
No. 9	10 3/8	15	15-0			0.988	163/254
No. 10	9 7/8	15	8-5 1/2	2000	161/250	0.71	226/352
No. 10-A (Edger)	14	3 3/4	4-2	50	200/800	...	...
No. 11	9 7/8	15	7-10			0.582	276/430

18-in. mills may be placed on these skids directly from the billet storage.

The furnace serving this mill is a continuous, side-charged, side-discharged unit, 31 x 25 ft, fired with coke oven gas. The heated billet is pushed from the furnace directly into the mill, which is located very close to the furnace.

The mill is a continuous train made up of five 12-in. stands, three 10-in. stands and three vertical edgers. Table VII gives some details of this mill. The five 12-in. stands and the first edger are driven through gearing by a 1300/2000-hp, 65 to 115.4-rpm, 6600-volt, a-c motor. The three 10-in. stands are driven through belts by a 2000-hp, 160 to 250-rpm, 6600-volt a-c motor. The second edger is driven by a 167-hp, 250 to 450-rpm motor and the third edger by a 50-hp, 200 to 800-rpm motor. A looping pit is provided before and after the second edger.

Babbitted bearings are applied on the roll necks of the first three horizontal stands and the first two edgers. All other horizontal stands use composition bearings. The third edger is equipped with roller bearings.

Normal rolling practice has reductions of 25 to 35 per cent in each roughing stand and 18 to 25 per cent in each finishing stand. Box type entry guides and double plate type delivery guides are located at each stand.

Skelp leaves the mill at speeds up to 1380 fpm and is sheared to desired lengths by a belt-driven rotary shear. The product is conveyed to two hot beds 35 x 20 ft and finally discharged on a hydraulic bar piler. Piles are then moved by crane to cooling skids.

The 10-in. skelp mill has a rated capacity of 25,000 tons per month, but has rolled as much as 555 tons in an 8-hr turn, 1503 tons in one day and 34,352 tons in a month. The average rate is 41 tons per hr.

CONTINUOUS WELD PIPE MILLS

Another part of Aliquippa's modernization program are two continuous butt weld pipe mills producing a size range of ½ to 4-in. nominal diameters. These mills have replaced two old style butt weld units wherein cut lengths of skelp were pulled, draw-bench fashion, through a welding bell.

No. 1 mill, which began operation in 1957, has a size range of ½ to 2 in. It is of conventional layout, with coil payoff, leveler, shear, flash welder, pinch roll and magnet roll units feeding the skelp into a continuous recuperative heating furnace.

The skelp first makes a double pass through a preheating furnace 102 ft-11¼ in. long x 3 ft wide x 9 ft high which is heated to about 1600 F by the waste gases from the heating furnace. The latter, 154 ft-5 in. long x 2 ft-6 in. wide x 2 ft-11 in. high, is fired either with coke oven gas or natural gas, under automatic temperature control. Fuel consumption averages 2,373,000 Btu per ton.

As the heated skelp leaves the furnace at about 2450 F, nozzles at the delivery end of the furnace blow air on the skelp edges, increasing their temperature to fusion point.

The skelp then passes through the mill, which consists of a forming pass, a welding pass and 12 reducing stands on 24-in. centers. Rolls are of 10½ in. nominal diameter x 6¾-in. roll body length. Each stand is individually driven by a 40-hp, 230-volt, 575/1975-rpm, d-c motor with the exception of No. 12, which has a 75-hp drive. Rolls operate in roller bearings.

In the first, or forming, stand, skelp is bent into an approximate horseshoe shape with the opening down.

Two continuous weld pipe mills will produce over 48,000 tons per month of pipe in sizes from ½ in. to 4 in.

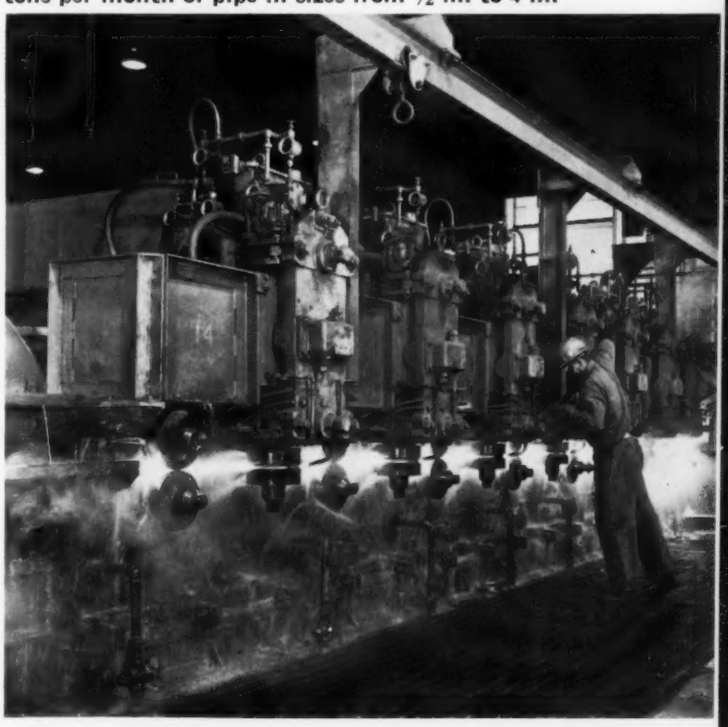


TABLE VIII
Butt Weld Pipe Mill Data

Stand No.	No. 1 Mill			No. 2 Mill		
	Motor hp	Gear ratio	Roll rpm	Motor hp	Gear ratio	Roll rpm
1	40	10.956	52.5/164.3	50	15.519	37.1/111.2
2	40	7.842	73.3/229.5	50	11.394	50.5/151.4
3	40	7.4	77.7/243.2	50	10.825	53.1/159.4
4	40	6.64	86.6/271.1	50	10.296	55.8/167.5
5	40	6.3	91.3/285.7	50	9.349	61.5/184.5
6	40	5.72	100.5/314.7	50	8.923	64.4/193.3
7	40	5.37	106.9/335.2	50	8.625	66.7/202.3
8	40	5.05	113.9/356.4	60	7.739	74.3/222.9
9	40	4.5	127.8/400.0	50	7.468	77.0/231.0
10	40	4.26	135.0/422.5	50	7.159	80.3/240.1
11	40	3.84	149.7/468.8			
12	75	3.48	165.2/517.2			
13	40	3.17	181.4/567.8			
14	40	3.03	189.8/594.1			

A welding horn located immediately after this stand has a lip which enters the opening of the bent shape to prevent twisting. The tip of the horn is drilled to permit jets of air or oxygen to impinge on the edges of the skelp.

The actual welding takes place in No. 2 stand, where rolls bring the skelp edges together under pressure. The remaining stands of the mill reduce the diameter of the pipe. The rolls in these stands are alternately vertical and horizontal so as to maintain roundness of the pipe. The reduction in each stand varies between 5 and 8 per cent. Mill speed varies with the size of pipe being produced, with a maximum of 1250 fpm.

The formed pipe, in a continuous length, passes on to a sizing mill.

A flying hot saw cuts the completed pipe into 42-ft lengths, which may then be divided into standard 21-ft lengths. After passing over a screw-type cooling bed, the pipe is quenched, straightened, faced and inspected. Hydrostatic testing, wherein five tubes are simultaneously subjected to 3000-psi pressure, completes the process. The pipe is then ready for shipping or for further work such as galvanizing, threading or coupling.

Skelp for No. 1 mill runs from 6⅝ to 13 in. in width and 0.102 to 0.24 in. in thickness. Coils weights range from 1500 to 8600 lb. Production rates vary with the pipe size being produced. The actual average is 31.6 tons per hr, but records have been set at 448 tons in an 8-hr turn and 1165 tons in one day. Power consumption averages 27.8 kwhr per ton, including mill drives and auxiliaries.

No. 2 mill, started up in 1958, is similar to No. 1 in principle but has a size range of 1¼ to 4 in. pipe. It uses skelp 12⅝ to 17½ in. wide and 0.121 to 0.359 in. thick, in coils weighing 2800 to 11,600 lb.

The four-zone furnace is 190 ft-9 in. long x 2 ft-9 in. wide x 2 ft-11 in. high. There is no preheating furnace on this mill.

No. 2 furnace has only eight reducing stands on 27-in. centers, with rolls of 14-in. nominal diameter x 7½ in. body length. This mill averages 50 tons per hr and has an 8-hr turn record of 471 tons. A maximum speed of 700 fpm is available.

Table VIII gives drive data for No. 1 and No. 2 mills. The mills draw power from two duplicate 500-kw, 250-volt d-c generator sets.

No. 1 mill was designed for a monthly tonnage of 20,600 tons, No. 2 for 27,520 tons.

Equipment for the production of lap weld pipe 2 to 4 in. in size still exists but has not been operated since 1958 as its size range is covered by No. 2 continuous weld mill.

ELECTRICWELD PIPE MILL

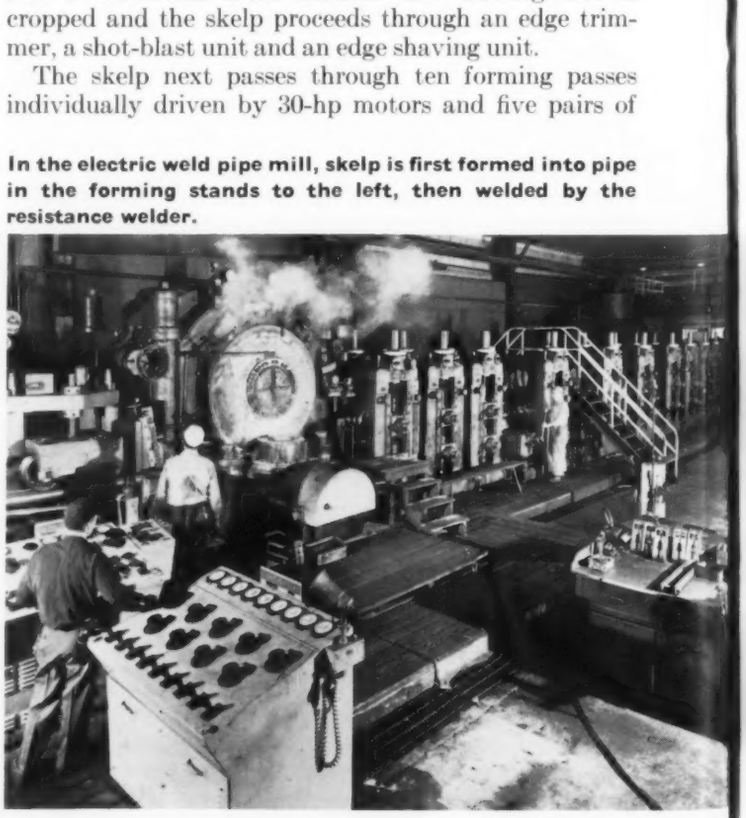
Another unit in J&L's expansion program is an electric resistance weld pipe mill designed to produce pipe of 4½ to 12¾ in. outside diameters from coiled skelp at speeds up to 150 fpm.

Skelp ranges 14½ to 40½ in. in width and 0.237 to 0.330 in. in thickness.

Coils 24 in. inside diameter and up to 60 in. outside diameter and weighing 7930 to 15,800 lb are put on a cone type uncoiler and the skelp is fed into pinch rolls and a seven-roll roller leveler. The leading end is cropped and the skelp proceeds through an edge trimmer, a shot-blast unit and an edge shaving unit.

The skelp next passes through ten forming passes individually driven by 30-hp motors and five pairs of

In the electric weld pipe mill, skelp is first formed into pipe in the forming stands to the left, then welded by the resistance welder.



vertical idler rolls. Here the skelp is rounded into tubular shape and delivered to the welding unit, where the seam is welded by electrical resistance.

Power for the welder is supplied by an oil-cooled electric resistance rotary welding transformer rated at 250,000 amp, 120 cycles per sec. Welding power is maintained at the proper amount for any mill speed by electronic control. Load cells on the welding passes of the mill measure roll pressures so that welding conditions may be reproduced as desired.

Weld flash, inside and out, is trimmed off by tungsten carbide cutters and planishing rolls then smooth down the weld on the outside.

After passing through a cluster of shaping rolls, the pipe goes through a seam annealer consisting of four 800-kw, 800-volt, 3000 cycles per sec induction heating units. These heat the weld and immediate surrounding metal to about 1300 F, relieving stresses in the weld. Next is a unit which operates on ultrasonic principles to monitor weld quality.

After the weld has cooled below the critical temperature, the pipe is quenched and then passes through a three-stand sizing mill and a straightener. A rotary head flying cutoff, synchronized with the speed of the mill, cuts pipe into lengths of 20 to 60 ft.

The pipe lengths are transferred to the finishing area, where they are put through a cross-roll straightener and pass on to inspection, facing and chamfering, hydraulic testing and stenciling.

This mill has a record month of 17,116 tons of pipe.

SEAMLESS TUBE DEPARTMENT

The seamless tube department consists of a steel conditioning area, a 30-in. round mill, two tube mills, and facilities for finishing and shipping tubes and for producing couplings.

Blooms of open hearth steel in various sizes, ranging from 7 x 7 in. to 13 x 13 in. are received in cars and unloaded in the conditioning yard. Here the blooms are usually pickled for about 20 min in an 8 per cent sulphuric acid solution. Defects brought to light by the pickling are then removed by spot scarfing or chipping. There are also two mechanical chipping machines and a gouging machine for use on certain grades of steel.

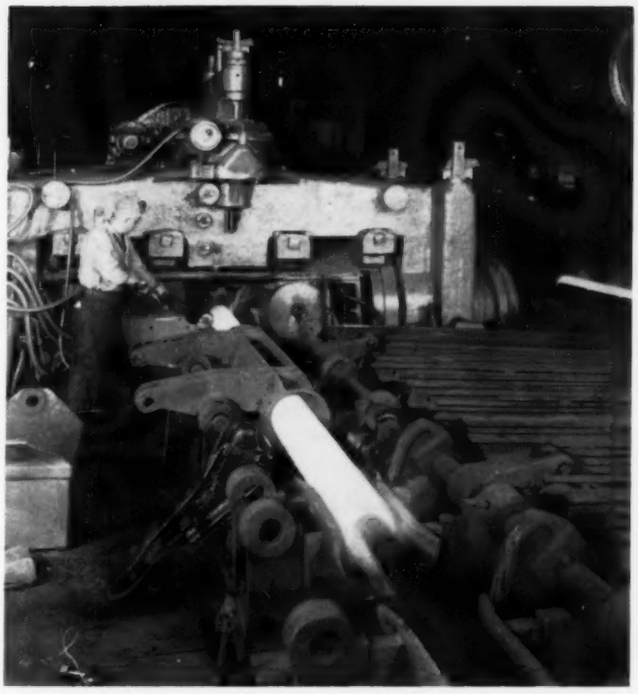
Conditioned billets are then heated in one of three continuous heating furnaces. Two furnaces are 20 ft wide x 80 ft long, while the third is 25 ft wide x 80 ft long. All are of end-charge, side-discharge design, and are fired with coke oven gas or producer gas, with oil as a standby. The furnaces are rated at 50 tons per hr each.

The heated bloom is moved over roller tables to the 30-in. mill, which is composed of three two-high-reversing stands placed side by side, all direct-driven by a 3000-hp 65 to 130-rpm, 650-volt d-c reversing motor. Two 1600-kw generators supply power for this drive.

On each side of the mill is a traveling table, 49 ft-6 in. long on the entry side, 45 ft on the delivery side.

Mill rolls are 32-in. in diameter with a body length of 83 in., and run in babbitted bearings with bronze inserts. Alloy steel rolls are used in the roughing stand, alloy iron in the two finishing stands.

This mill produces rounds of 5 to 10 in. diam for No. 1 tube mill, and 3½ to 6 in. diam for No. 2 tube mill.



In the production of seamless tube, heated rounds are first put through a piercer, where they are forced over a piercer point on the end of a mandrel bar.

An average rolling rate of 66.9 net tons per hr is maintained, but records of 939 tons per 8-hr turn, 2459 tons per day, and 51,800 tons per month have been made. Power consumption averages about 28 kwhr per ton rolled.

The size of the round varies with the size of tube to be produced as follows:

Round diameter, in.	*Outside diameter of tube, in.*
3½	2⅜
4	2⅞
4½	3½
5	4½
5 or 6	5½
5¾	6⅝
5¾ or 6½	7
6½	7⅝
7	8⅝
7 or 7½	9⅝
7½ or 9	10¾
9 or 9½	12¾
9½	12⅜
9½	14

Finished rounds, 50 to 60 ft long, are then cut into desired lengths at either of two hot saws. One saw, a screw-operated sliding type, is 54 in. in diameter and cuts rounds up to 10-in. in diameter. It is located in line with the second mill stand, and 199 ft away. The other saw, of swinging type, has a 50-in. blade and cuts material up to 6-in. in diameter. It is in line with the third mill stand, and 142 ft away.

After sawing, each piece goes to a centering machine, where an indentation is made in the center of one end. The rounds are then transferred by buggy to the seamless mills, which are located in another building a short distance away.

TABLE IX
Seamless Tube Mill Drives

	Roll size, in.		Motor hp	Motor voltage	Motor rpm	Gear ratio	Roll rpm
	Nominal diameter	Body length					
No. 1 Mill							
No. 1 piercer	40	24	3000	6600 a-c	250	3.095	81
No. 2 piercer	40	24	3000	6600 a-c	250	3.095	81
Plug mill	38	56	1500	6600 a-c	375	5.560	67
Reeler	30	28	500	230 d-c	400/800	3.755	105/210
Reeler	30	28	500	230 d-c	400/800	3.755	105/210
Sizing mill (5 stands)	28½	17	400	6600 a-c	490	4.053	121
No. 2 mill							
Piercer	40	20	2000	6600 a-c	250	3.182	79
Plug mill	28	55	1000	6600 a-c	375	3.780	99
Reeler	30	23	350	230 d-c	275/550	4.017	68/136
Reeler	30	23	350	230 d-c	275/550	4.017	68/136
Reducing mill (12 stands)	15½	9	400	6600 a-c	500	8.167	61
Reducing mill (12 stands)	15½	9	400	6600 a-c	500	8.167	61
Sizing mill (5 stands)	18½	11	250	220 a-c	500	5.770	87
Stretch reducing rougher (7 stands)	14½	9	(7) 200	600 d-c	850/1750	3.353	60/150
Stretch reducing finisher (9 stands)	12	6¼	(9) 200	600 d-c	850/1750	2.304	200/450

At the seamless mills, the rounds are reheated in four end-charge, side-discharge, continuous furnaces. Three of these are 20 ft wide x 57 ft-1½ in. long, the fourth is 25 ft wide x 66 ft long. The hearths of all furnaces slope 1½ in. per ft, so the billets roll down toward the discharge end. The furnaces are fired with coke oven gas or fuel oil. Fuel consumption averages 2,510,000 Btu per ton.

These furnaces discharge rounds heated to 2150 to 2250 F, depending on the type of steel, onto a common conveyor table, so that any furnace may feed to either of the two mills if necessary.

No. 1 seamless mill has a size range of 5½ to 14⅜ in. diam tubes, in lengths of 22 to 46 ft. The heated billet is conveyed to the first piercer, a heavily designed unit with conical, cast alloy steel rolls which revolve the billet as it is forced over the piercer point on the mandrel bar.

This shot blast unit is used in processing tube ends in the seamless specialties department.

The first piercer transforms the solid round into a hollow cylinder which is then transferred to the second piercer, which is essentially a duplicate of the first. Here the hollow cylinder is expanded and elongated by being forced over another mandrel plug.

The rough tube is then transferred to the plug (or high) mill, where it is further rolled out over a plug to the approximate wall thickness desired.

Following this, two reelers again roll the tube over mandrels, slightly expanding the diameter and smoothing the inside and outside surfaces.

Finally, the tube is finished to the desired outside diameter in the sizing mill, which consists of five stands of grooved rolls driven by a single 400 hp motor.

Table IX gives data on the drives of the seamless tube mills.

No. 1 tube mill is a high production unit and often rolls 18 to 20 miles of line pipe per day. Tonnagewise, this mill turned out as much as 2012 tons in a day and 34,592 tons in a month.

Power consumption averages 30 kwhr per ton of product on this mill.

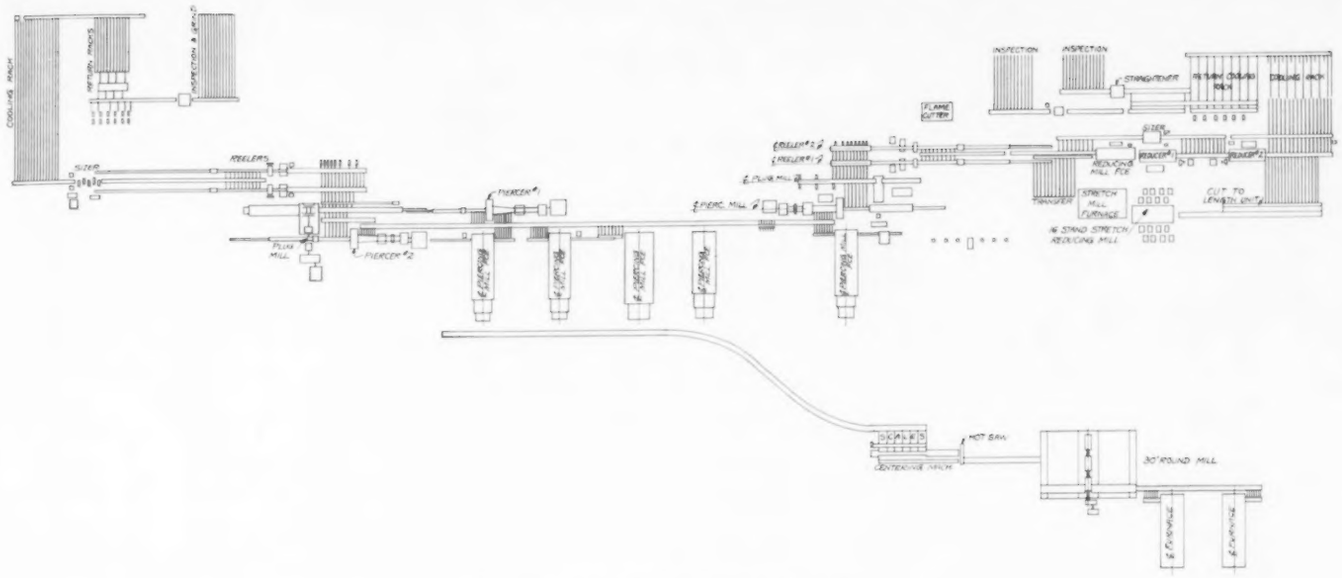
No. 2 seamless mill produces tubes of 2⅜ to 6 in. outside diameter in 22 to 44-ft lengths. It differs somewhat from No. 2 mill. Because of the smaller sizes, only one piercing unit is installed.

The pierced billet then goes, as in the larger mill, to the plug mill and to the reelers. From this point, it may go to a five-stand sizing mill, or it may be put through a reheating furnace and then through one or two reducing mills, each consisting of 12 stands on 36-in. centers, or it might go through a reheating furnace to a 16-stand stretch reducing mill.

No. 2 mill consumes about 45 kwhr per ton of product. This mill's tonnage is about half of that of No. 1, records having been set at 996 tons in a day and 19,337 tons in a month.

The two tube mills work with opposite directions of product flow. Tubes from each mill are conveyed to the finishing floor on long cooling racks which operate slowly to permit the tubes to cool sufficiently to be straightened when they arrive at the end of the rack.

After straightening, the product is put throug



General plan of seamless tube mills.

various finishing operations, depending on the class of product. All types are routed to cutting-off machines followed by inspection and seam grinding. In some cases, an upsetting operation precedes the final finishing.

Product requiring threading then goes to threading machines and is then inspected and tested, after which it is marked, provided with thread protectors and couplings, and stocked or shipped. Some grades are normalized and inspected after straightening before the other operations. Other processes are also used to meet special customer requirements.

A separate shop makes couplings for the seamless products.

A recent addition to tube producing facilities is the seamless tube specialties department. Located in a building 100 x 725 ft are two hearth-type gas-fired furnaces, with a water spray quenching unit between them. One furnace is a high-temperature unit which is used to heat for quenching or for normalizing. The other is a tempering furnace, for use after quenching. By careful heat treatment, high strength seamless pipe may be produced with lower alloy contents than were formerly needed.

Other equipment in the new building includes a three-stand sizing mill, a rotary straightener, a gag-press straightener, cut-off and threading equipment and storage racks.

ROD AND WIRE MILL

Wire forms an important item in the production of Aliquippa Works. To supply rod for the production of wire, a new three-strand rod mill was installed in 1951, replacing two old mills. This mill is currently producing rods from $\frac{7}{32}$ to $\frac{21}{32}$ in. inclusive, but this range can be increased to $1\frac{1}{8}$ in. if desired. All sizes may be triple-stranded.

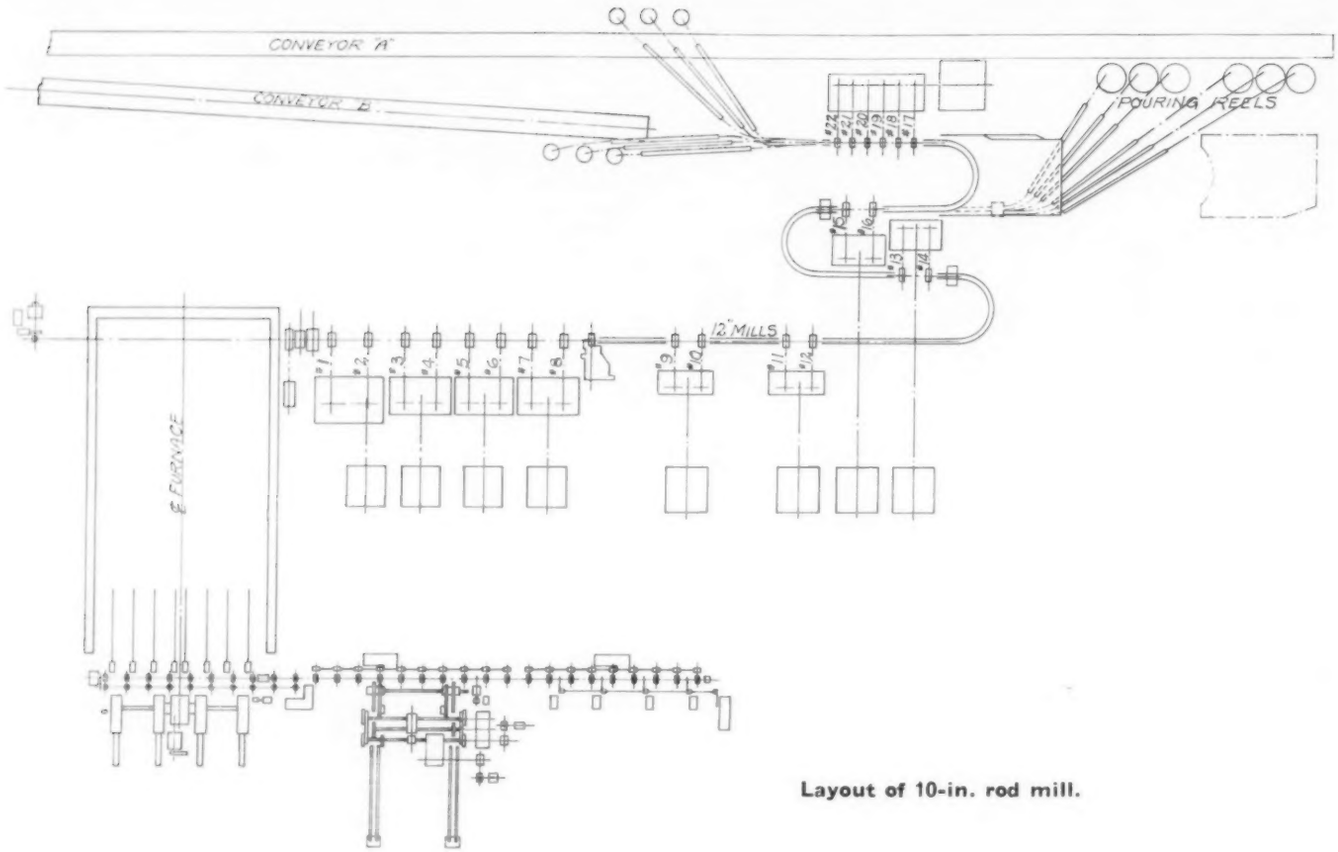
The new mill is supplied with $2\frac{1}{2}$-in. square billets, 30 ft long, from the billet mill. Billets are loaded on a bundle buster which separates the billets and feeds them, one by one, to the furnace charging table.

Billets are heated in an end-charged, side-discharged, continuous heating furnace 33 ft wide x 65 ft long, rated at 90 tons per hr. This furnace is fired by natural or coke oven gas, in a two-zone heating arrangement. Complete automatic furnace controls are provided. Fuel consumption averages 1,130,000 Btu per ton.

As a heated billet is pushed from the furnace, it passes through a pair of pinch rolls and a hydraulically operated switch which directs the billet into the proper pass line. There is also a safety shear here to cut up the billet in case of a cobble in the roughing train.

The roughing train consists of eight stands (two 16-in., six 15-in.) in line. The intermediate train is made up of eight 12-in. stands, four of which are in line with the roughing train, while the other four are placed in two pairs. Repeaters reverse the flow of the steel after stand No. 12 and after stand No. 14. A third repeater after stand No. 16 leads the steel back into the finishing

This three-strand rod mill has a maximum delivery speed of 6400 fpm. It averages about 45 tons per hour but has produced 1457 tons in a single day.



Layout of 10-in. rod mill.

train, which consists of six stands, two of 10.063-in. pitch diameter, two of 10.5 in., and two of 11 in.

All roughing and intermediate stands are driven in pairs by 500 or 800-hp motors, while a single 2000-hp motor drives the finishing train. All of these motors are 600-volt, d-c units. The motors on the roughing and finishing stands receive power from two 1500-kw, 600-volt generators, the intermediate stand drives from a 2250-kw generator. Table X gives data on the individual stands and their drives.

Power consumption averages about 100 kwhr per ton for main drives, auxiliaries and lighting.

In all stands, both top and bottom rolls may be adjusted, and are separated by hydraulic pressure. Roller bearings are applied to all roll necks, gear sets and pinions. All stands are driven through gear-type couplings. Roughing and intermediate stands are mounted on sliding bases and are shifted by hydraulic cylinders to maintain pass lines.

The mill is lubricated by three automatic grease systems and three circulating oil systems.

Cast iron guides are used in the roughing and intermediate trains, with roller twist guides to turn the diamond and oval sections. Bronze guides are used in the finishing train.

Diamond and square passes are used in the roughing train, and oval and square passes in the intermediate and finishing stands. The front end of the billet is cropped by an electrically operated flying shear between the roughing and intermediate trains.

Pass reduction are of the order of 20 to 25 per cent in the roughing stands, 15 to 25 per cent in the intermediate stands, and 10 to 20 per cent in the finishing stands.

Sections from $\frac{7}{32}$ in. up to and including $1\frac{1}{32}$ in. are finished out of the finishing train, with stands being removed in pairs from the finishing train as the size goes up.

Rod leaving the finishing train goes to one of six laying reels, where it is coiled. High-pressure water jets between the mill and the reel serve to reduce the temperature of the rod.

Cold drawing of wire is performed principally on continuous multiple spindle machines. Wire is drawn in sizes ranging from 0.006 in. to 1 in. in diameter.

TABLE X
10-In. Rod Mill

Stand	Nominal diameter, in.	Body length in.	Distance from preceding stand, ft-in.	Motor hp	Motor rpm	Gear ratio	Roll rpm	Roll face speed, fpm
No. 1	16 7/8	28	...	500	300/900	32.986	9.09/27.28	38/114.15
No. 2	17 1/8	28	7-0			25.815	11.62/34.86	47.95/143.86
No. 3	16 1/8	28	7-0	500	300/900	18.545	16.18/48.53	64.1/192.31
No. 4	16 1/8	28	6-0			14.424	20.29/62.39	82.08/246.23
No. 5	16 1/8	28	6-3	500	300/900	11.036	27.19/81.55	110/330
No. 6	16 1/8	28	6-0			8.583	35/105	140/421
No. 7	16 1/8	28	6-0	500	300/900	6.493	46.3/139	188/565
No. 8	16 1/8	28	6-0			5.050	59.3/178	240/721
No. 9	12 3/8	26	21-4	800	300/900	3.820	79/236	260/779
No. 10	13 1/16	26	5-0			3.00	100/300	332/995
No. 11	12 13/16	26	16-4	800	300/900	2.9375	102/306	340/1021
No. 12	13 1/16	26	5-0			2.2708	132/396	438/1315
No. 13	12 29/32	26	...	800	300/900	1.7544	171/513	579/1737
No. 14	13 1/16	26	5-0			1.4035	214/641	711/2132
No. 15	13 1/16	26	...	800	300/900	1.250	240/720	807/2420
No. 16	13 1/16	26	5-0			1.0417	288/864	964/2907
No. 17	10 3/16	20	...			0.6064	495/1120	1320/2990
No. 18	10 9/16	20	3-0			0.5242	573/1297	1535/3476
No. 19	10 21/32	20	3-0	2000	300/900	0.4507	666/1508	1837/4160
No. 20	10 63/64	20	3-0			0.3990	752/1704	2106/4772
No. 21	11 1/8	20	3-0			0.3417	878/1989	2523/5716
No. 22	11 1/2	20	2-10			0.3107	966/2187	2825/6400

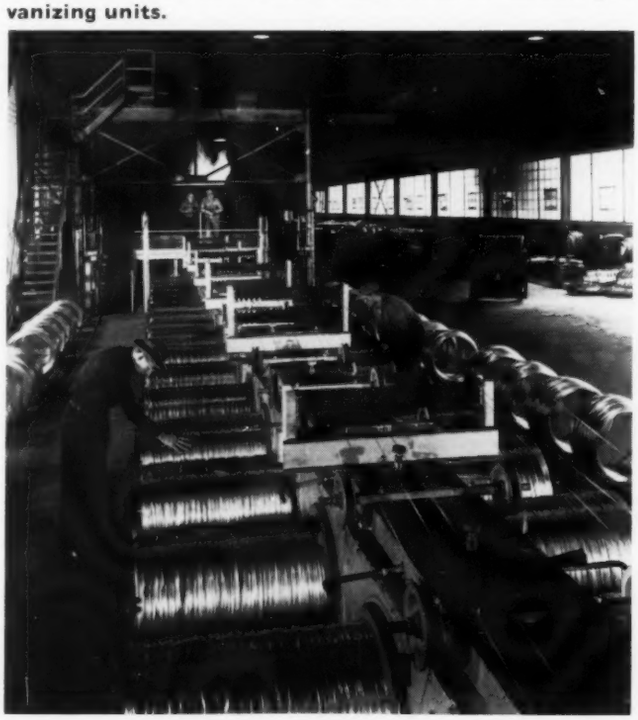
Sizes of 23/64 in. and larger do not go through the finishing train, but are finished out of the intermediate stands. Here again, as the size goes up, stands are removed in pairs from the intermediate train. At the current maximum size of 21/32 in., only four of these stands remain in the mill.

Rod finished out of the intermediate train is coiled in one of six pouring reels.

Coils from the laying or pouring reels are discharged on to a drag conveyor system, transferred to a hook-type conveyor and transported to a storage area until loaded for shipment or for use in the wire mill.

Maximum speeds of 6400 fpm out of stand No. 22 and 2907 fpm out of stand No. 16 are available, but actual finishing speeds are generally somewhat lower.

Wire and wire products form an important part in Aliquippa's product mix. Shown here is one of the wire galvanizing units.



The mill averages about 45 net tons per gross operating hour, but has produced as much as 85 tons in one hour, 562 tons in an 8-hr turn, 1457 tons in a day and 31,387 tons in a month.

In the wire mill, hot rolled rod is processed into a full range of wire sizes (from 0.007 to 1.0 in.) and grades. Rods are first pickled to remove scale from the hot rolling, then given a lime coating and baked.

Cold drawing is performed on 13 individually driven single spindle blocks, 72 group driven frame type blocks, 39 continuous multiple spindle machines with four or less spindles, 43 continuous machines with five or more spindles, and 18 continuous wet drawing machines. This drawing equipment can produce material running from 0.006-in. diam up to 1-in. diam.

To meet desired physical characteristics and finish, an extensive layout of auxiliary processing equipment is provided. Four gas or oil-fired furnaces handle multiple strands of wire for in-process annealing of high carbon grades. There are also three strand-annealing units in which the wire is heated by electric resistance. Two of these units may be converted to produce oil-tempered finished mechanical spring wire. In addition, five bell-type furnaces with 14 bases and neutral atmosphere equipment may be used for in-process annealing or finish annealing of wire coils.

Galvanizing equipment consists of three large units capable of producing various galvanized coatings, and another unit for coating fine wire.

A full line of nails and staples are produced on 148 nail machines and four staple machines. Equipment for sterilizing, galvanizing or coating, cleaning, weighing and packaging these products is provided. Wire fence is made by seven field fence machines and 18 barbed wire machines. Ten straightening and cutting machines are available for the production of cut material ranging from reinforcing bars to florist wires.

STRIP MILL

A major unit in the Aliquippa modernization project is a 44-in. semi-continuous hot strip mill, designed to produce hot rolled bands 9½ to 41½ in. in width and 0.048 to 0.375 in. in thickness.

The mill is located in a building 62 ft wide x 936 ft long, adjacent to the blooming mill, from which slabs are brought to the slab yard over a system of transfers.

Slabs coming to the mill range 12½ to 40¾ in. in width, 5½ to 9 in. in thickness, 99 to 290 in. in length and 4300 to 24,000 lb in weight. The slabs are brought from storage by crane and placed on a magazine elevator feeder from which they move to the furnace charging table, 122 ft long and driven by four 50-hp mill-type motors.

There are two continuous slab heating furnaces, each rated at 150 tons per hr. They are 86 ft long overall and have hearths 68 ft long x 26 ft wide. They are fired with coke oven gas or natural gas, with eight burners above and eight burners below in the heating zone and ten burners overfiring the soaking zone. The furnaces have suspended roofs with 2½ in. insulation. Sidewalls carry 5½ in. of insulation and 10 in. of insulation beneath the hearth.

Air for combustion is supplied by a 50,000-cfm fan for each furnace. The air is preheated to 600/655 F in metallic tubular recuperators. Burner capacity for each furnace totals 196,000,000 Btu per hr.

Each firing zone of each furnace is equipped with a fuel input control, fuel-air ratio control and temperature control. Each furnace also has a furnace pressure control. Fuel consumption averages 1,650,000 Btu per ton.

Slabs are moved through the furnace by a double rack-and-pinion pusher driven by two 75-hp mill-type motors. Through the action of the pusher, a slab is expelled from a furnace on to the mill approach table.

The first stand of the mill is a vertical edger with rolls 40 in. in diameter x 13¼-in. body length. It is driven by two 500-hp, 440-volt, 60-cycle, 360-rpm motors. This motor drives through a 17.7 gear ratio to give roll speed of 20.4 rpm or about 212 fpm face speed.

The edger is capable of taking heavy edging drafts and is very effective in cracking scale from the slab. Edger rolls are adjusted by two 50-hp motors.

The second stand is a universal reversing rougher, placed about 30 ft from the edger. This is a two-high 44 x 44-in. unit with babbitted bearings on the roll necks. The top roll is hydraulically balanced and is moved up and down by mill screws of 14-in. diam, 1½-in. pitch driven by two 75/150-hp motors under adjustable voltage control. A magnetic clutch permits the two screws to be operated separately or in unison. Maximum roll opening is 14 in. and a maximum screw travel speed of 96.5 in. per min is available.

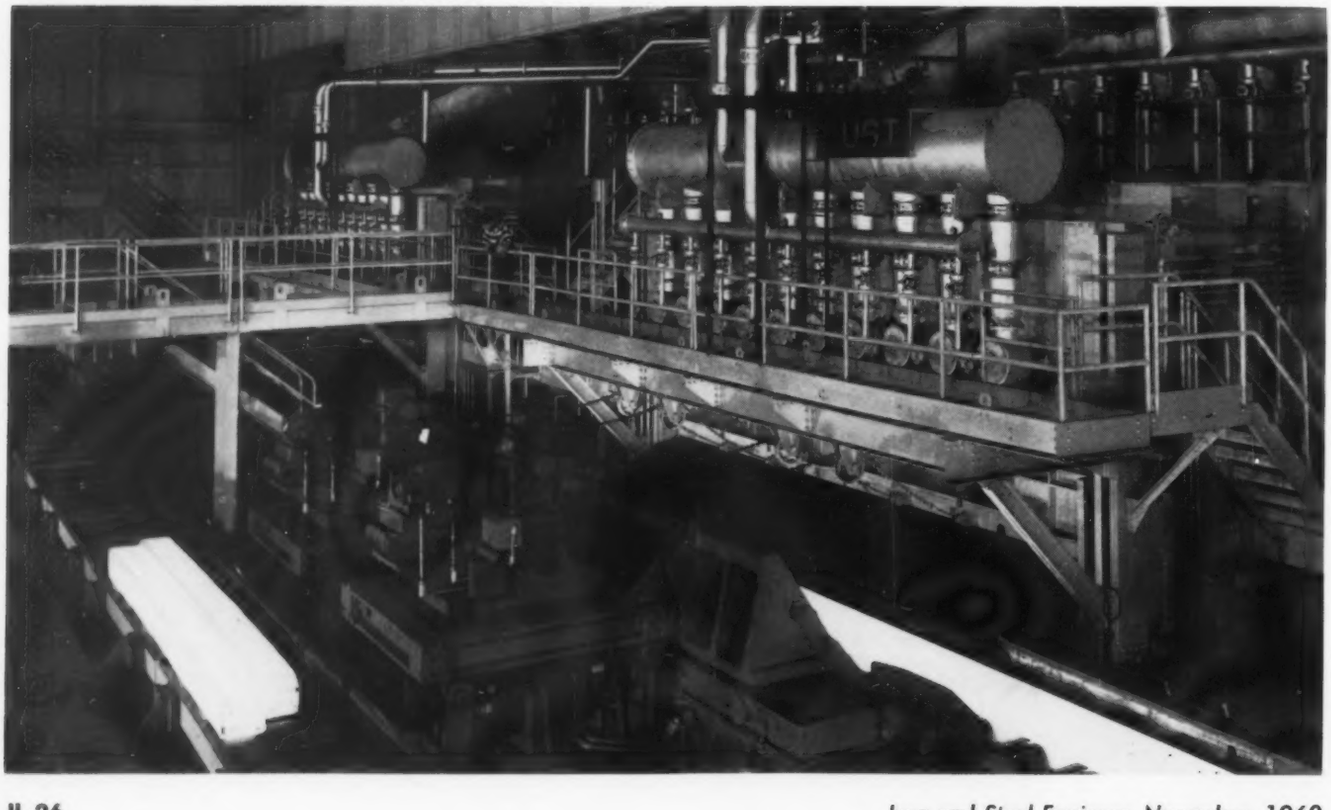
The rougher is driven by two 3000-hp, 700-volt, 40/100-rpm d-c motors in twin drive. These units draw power from a motor-generator set consisting of two 2500-kw, 700-volt d-c generators, a 1250-kw, 460-volt d-c generator and an 8500-hp, 6600-volt, 514-rpm synchronous motor. Each of the 3000-hp motors is connected to an individual generator.

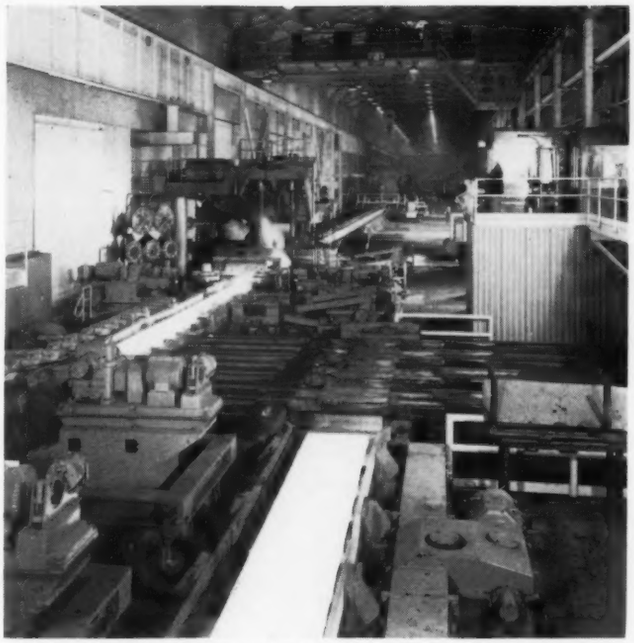
Rolling speeds range 115 to 1150 fpm.

The roughing stand also has vertical edging rolls set 6 ft ahead of the horizontal rolls. The vertical rolls are 24 in. in diameter, with a body length of 17½ in. They operate in bronze bearings and are driven by two 375-hp, 230-volt, 360/450-rpm d-c motors connected in parallel and powered from the 1250-kw generator previously mentioned. Edger roll adjustments are made by two 50-hp mill type motors.

Front and back tables on the rougher have rollers

Two heating furnaces, rated at 150 tons per hour each, serve the strip mill. The blooms to the left are enroute from the bloomer to storage in back of the furnaces.





This view shows the vertical edger and universal reversing rougher of the 44-in. strip mill. In the foreground is the transfer and table which handle slabs or blooms from the bloomer to the storage area.

16 in. in diameter x 4 ft long on 24-in. centers, individually driven by 10-hp d-c motors under adjustable voltage control.

The reversing rougher can be operated under completely automatic control by a card-programmed system, whereby punched cards are prepared with a complete rolling schedule on each. A card is made for each slab size, strip size and grade of steel, using the drafts and speeds deemed best. Roll opening can be adjusted in $\frac{1}{32}$ in. increments from zero to 14 in. Integral edger roll openings can be adjusted in $\frac{1}{16}$ in. increments from 6 to 44 in. Mill speeds may be set at 115, 300, 440, 715, 880 or 1100 fpm. Edger speed is automatically adjusted to match main roll speed, with due allowance for the draft in the horizontal rolls.

A radiation detector which responds to the hot strip on the mill table is located on each side of the mill. They initiate the slowdown when the tail end of the strip approaches the mill. As soon as strip leaves the mill rolls, load detectors initiate action to reposition rolls and re-enter the steel in the mill.

Edging stand adjustments are also controlled by the system.

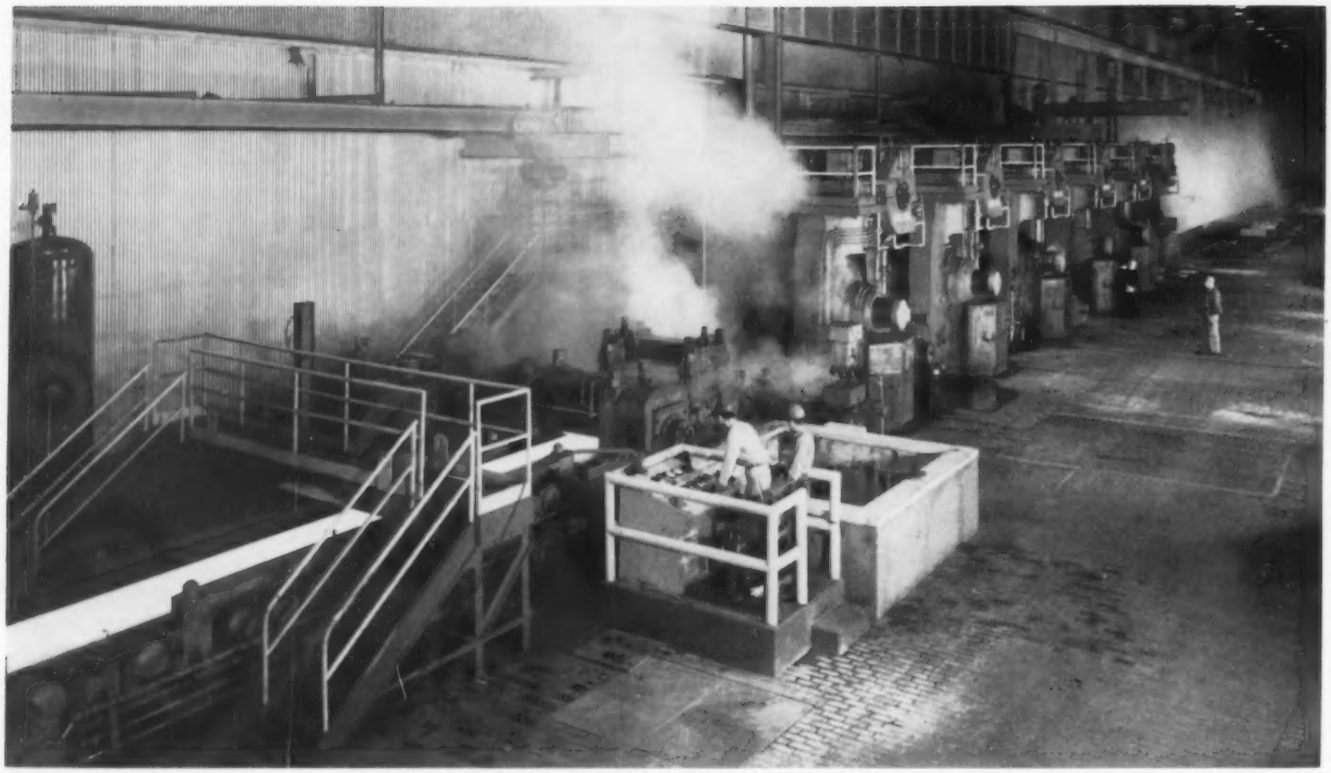
Under automatic operation, a punched card corresponding to the desired rolling schedule is inserted in the card reader. Pressing the "schedule advance" button causes data from the card to be transferred to the programming equipment. Pressing the "pass advance" button sets the mill for the first pass. After the slab is introduced to the mill, settings for each successive pass proceed automatically. The schedule will be repeated for each slab until the "schedule advance" button causes the schedule on the next card in the card reader to be set up.

The rougher can be scheduled for a maximum of nine passes.

Leaving the rougher, the steel passes over a delay

TABLE XI
Strip Mill Data

Stand	Diameter, in.		Roll body length, in.	Distance from preceding stand, ft-in.	Motor data				Gear ratio	Roll rpm	Roll face speed, fpm
	Work roll	Back-up roll			Hp	Voltage	Type	Rpm			
Hot mill											
Edger scalebreaker	40	...	13¼	...	500	440	a-c	360	17.7	20.4	212
Universal edger	24	...	17½	24-6	(2) 375	230	d-c	360/450	6.0	60/75	750/950
Reversing rougher	44	...	44	6-0	(2) 3000	700	d-c	40/100	Direct	0/40/100	0/1150
No. 1 edger	25	...	9	247-11	(2) 150	250	d-c	460/920	14.9	30.8/61.6	202/404
No. 1 finisher	22½	44	45	8-3	3000	750	d-c	225/430	6.33	35.5/68.0	209/400
No. 2 finisher	22½	44	45	18-0	3000	750	d-c	225/430	...	63.5/121	373/710
No. 3 finisher	22½	44	45	18-0	3000	750	d-c	90/180	Direct	90/180	530/1060
No. 2 edger	15	...	6½	6-10	(2) 75	250	d-c	515/1030	3.68	140/280	587/1175
No. 4 finisher	22½	44	45	11-2	3000	750	d-c	125/250	Direct	125/250	735/1471
No. 5 finisher	22½	44	45	18-0	3000	750	d-c	150/300	Direct	150/300	881/1762
No. 3 edger	15	...	6½	6-10	(2) 75	250	d-c	515/1030	1.93	268/535	1122/2241
No. 6 finisher	22½	44	45	11-2	3000	750	d-c	200/400	Direct	200/400	1178/2356
Tandem cold mill											
No. 1 stand	21½	53	42	...	1750	750	d-c	80/240	Direct	80/240	450/1351
No. 2 stand	21½	53	42	13-6	(2) 1750	750	d-c	150/360	Direct	150/360	844/2026
No. 3 stand	21½	53	42	13-6	(2) 1750	750	d-c	175/350	0.655	267/534	1502/3004
No. 4 stand	21½	53	42	13-6	(2) 1750	750	d-c	200/400	0.5	400/800	2251/4503
No. 5 stand	21½	53	42	13-6	(4) 1000	750	d-c	275/535	0.5	550/1070	3096/6023
Reel	...	...	...	...	(2) 300	375	d-c	300/1200	...	...	...
Temper mills											
Entry puller	...	...	...	...	300	600	d-c	850/1500	Direct	850/1500	...
No. 1 stand	19	49	48	...	(2) 400	600	d-c	400/600	Direct	400/600	5130/7692
No. 2 stand	19	49	48	13-0	(2) 600	600	d-c	1150/1500	Direct	1150/1500	5715/7450
Exit puller	...	...	...	...	(2) 600	600	d-c	850/1500	Direct	850/1500	...
Tension reel	...	...	...	...	600	375	d-c	300/1500	0.987	303/1515	...
Temper mill	19	39¾	42½	...	250	250	d-c	540/1000	Direct	540/1000	2690/4975
Tension reel	...	...	...	...	400	...	...	440/1750	...	...	...
Temper mill	19	39¾	42½	...	250	250	d-c	540/1000	Direct	540/1000	2690/4975
Tension reel	...	...	...	...	400	...	...	440/1750	...	...	...



The hot strip finishing train has six 22½ in. and 44 in. x 45 in. four-high stands, each driven by a 3000-hp motor. Maximum delivery speed is 2356 fpm.

table composed of rollers 14 in. in diameter x 4 ft long on 36-in. centers. Each roll is driven by a 7½-hp d-c motor under adjustable voltage control.

The first unit of the finishing train, a vertical edger, is located 247 ft-11 in. from the roughing stand. It has rolls $^{24}/_{26}$ in. in diameter, of 9-in. body length, running in roller bearings. They are driven by two 150-hp, 250-volt, 460/920-rpm d-c motors. A gear ratio of 14.9 gives roll speeds of 30.8/61.6 rpm or about 200/400 fpm surface speed. Edger roll adjustments are made by two 15-hp motors. A distance of 8 ft-3 in. separates this edger from the first finisher.

The six finishing stands are all 22½ in. and 44 x 45 in. four-high units, with roller bearings on the work rolls and oil-film bearings on the backups. They are spaced on 18-ft centers. Mill screws on each stand are driven by two 75-hp motors connected by a magnetic clutch.

Each stand is driven by a 3000-hp, 750-volt d-c motor, the first two through speed reducers, the last four direct. Motor speed, gear ratios, etc., are given in Table XI.

Two more separate vertical edgers are built into the finishing train, one between No. 3 and No. 4 finishers, and one between No. 5 and No. 6 finishers. These units have rolls 14 to 16 in. in diameter x 6½ in. barrel length. Each stand is driven by two 75-hp, 515/1030-rpm d-c motors through reductions of 3.68 and 1.93 respectively, giving roll speeds of 140/280 rpm (587/1175 fpm) and 268/535 rpm (1122/2241 fpm). Roll adjustments by two 1½-hp motors on each edger.

The three edgers on the finishing train are primarily for rolling bevel-edged material for pipe production.

The main drive motors of the finishing train draw power from two duplicate motor-generator sets, each consisting of three 2500-kw, 750-volt d-c generators driven at 514 rpm by a 10,500-hp, 6600-volt synchronous motor. Each generator is connected to an individual drive motor to provide great flexibility for speed control, allow a wide speed cone and limit the possible short circuit current. Voltage regulators on each generator with IR drop compensation are provided in order to hold accurate motor terminal voltage and stand speed regardless of load. Main motor fields are provided with current regulators for accurate control of motor field current. The stable field control resulting eliminates motor speed change due to changes in field temperature and offers rapid speed change by field control.

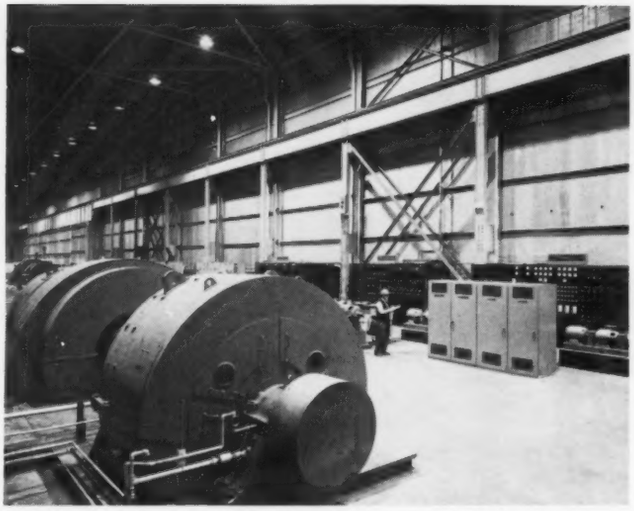
Motor-actuated loopers are provided between the finishing stands to take up slack that may occur in the strip while rolling.

To insure good surface on the rolled product, hydraulic sprays for descaling the strip are located on both sides of the reversing rougher and at the entry of the finishing train. Water for these sprays comes from two six-stage, 1800-gpm, 1300/1620-psi centrifugal pumps. Steam jets are also installed at the same locations.

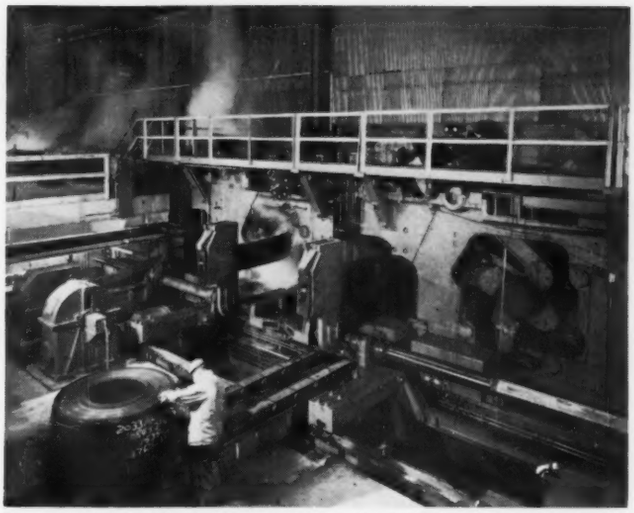
The hot mill motor room, 56 ft wide x 460 ft long, contains the main mill drives with their reduction gears, control equipment, switchgear and motor-generator sets previously mentioned. Here also are the motor generator sets supplying adjustable voltage power for the screwdowns, mill and runout tables, edgers, loopers and coilers.

Rotating machinery in the motor room is cooled by air forced from the room down through the units, through surface type air coolers and filters, and back into the room.

Leaving the finishing train, strip proceeds over a runout table to two driven-mandrel type downcoilers about 310 ft away, capable of forming strip 9½ in. to



View of the hot strip mill motor room. To the right are cabinets holding the memory and decision-making equipment of the roughing stand's card programming control.



The two hot strip coilers form coils of 24 in. inside diameter and up to 60 in. outside diameter (650 lb per inch of width).

41½ in. wide and 0.048 in. to 0.375 in. thick into coils of 23 to 24½ in. inside diameter, 60-in. outside diameter, with a maximum weight of 650 lb per inch of width.

The 193 rollers in the runout table are 12 in. in diameter x 4 ft-2 in. long, on 18-in. centers, and are individually driven by 3-hp d-c motors under adjustable voltage control.

The mandrel of each coiler is driven by a 200-hp, 230-volt, 125/375-rpm d-c motor, with 15-hp motors on the wrapper rolls. Power driven rotary side guides are placed ahead of the coilers to eliminate edge damage, especially on bevel-edged skelp. Coils are pushed from the coiler mandrel on to a matching mandrel on a coil transfer car which in turn places them on a twin-chain discharge conveyor. They are carried to a banding station and then on a saddle type conveyor to the unloading station. When rolling skelp, two or three coils are further banded edge to edge for convenience in handling.

From the unloading station, coils are moved to the consuming departments by straddle trucks equipped with a 12-ft ram on which the coils hang.

TIN MILL

The tin mill at Aliquippa was modernized and expanded in 1947, replacing old facilities for tinplate production. It now occupies about 20 acres toward the south end of the plant and has an annual rated capacity of 600,000 net tons.

Hot rolled coils, averaging 15,000 lb in weight, come from the 44-in. hot strip mill. They are first cleaned of all hot-mill scale by pickling in a continuous line rated at 59,000 tons per month. The entry end of this line is composed of the usual expanding mandrel feed reel, a scale-breaking processor, a shear for trimming coil ends, an electric flash butt welder, a looping pit and pinch rolls.

Next in line are four pickling tanks 80 ft long x 6 ft-4 in. wide x 5 ft-4 in. deep, constructed of rubber covered steel plate and lined with 10 in. of brick set in acid resistant cement. Each tank holds about 19,000 gal of solution containing, in the various tanks, 10 to 18 per cent sulphuric acid. These tanks are covered and vented to a fume disposal system. The pickling solutions are held at 200 to 210 F by the injection of steam.

Immediately after the acid tanks are a cold water rinse tank and a hot water rinse tank, followed by a dryer, an edge trimmer, an oiler and a recoiling reel. Coils formed here are made up of several of the hot rolled coils, and are approximately 72 in. outside diameter.

The pickling line is driven under adjustable voltage control and operates at speeds of 300 to 600 fpm.

Pickled coils are then ready for the cold reduction process, which is carried out in a five-stand, four-high 21½ in. and 53 in. x 42 in. tandem mill, some details of which are given in Table XI.

This mill is of unusually heavy construction. Roller bearings are applied to all work roll necks, with oil-flooded bearings of 3,000,000-lb capacity each on the back-up roll necks. Screwdowns on each stand are operated by two 75-hp mill type motors under adjustable voltage control.

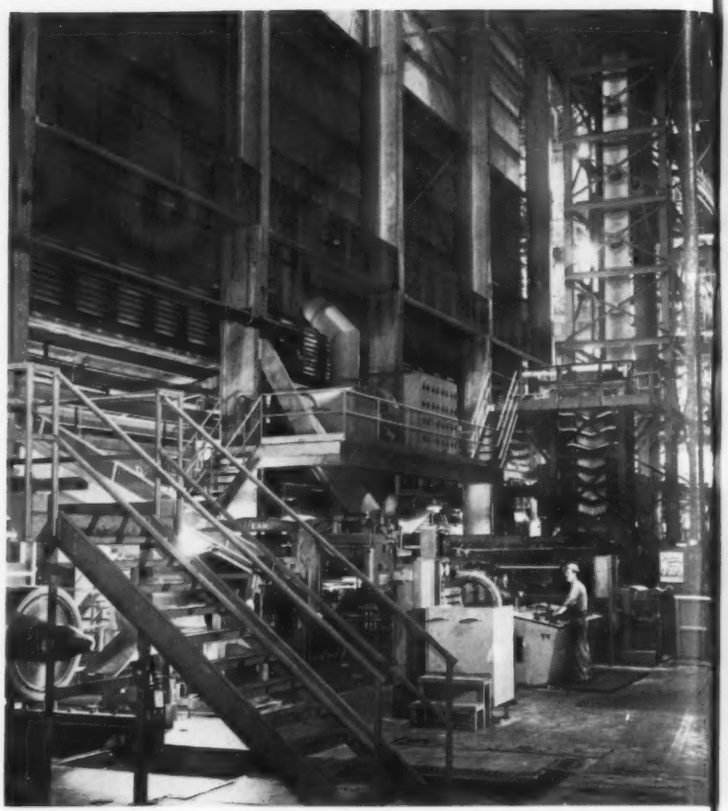
As may be noted from Table XI, the main drives of this mill are rather unusual. No. 1 stand has a single motor drive through pinions. No. 2 stand is also driven through pinions by two motors in tandem on one shaft. No. 3 is a twin drive with a separate motor driving each work roll through speed-increasing gears. No. 4 stand is similar to No. 3, but with a different gear ratio. No. 5 stand is also a twin drive through speed-increasing gears but has two motors on each work roll. This arrangement was used to keep inertia of the drives at a minimum.

The drive motors operate under adjustable voltage control, drawing power from two motor-generator sets with a separate generator for each stand drive. No. 1 stand is served by a 1500-kw generator, No. 2 and No. 3 stand by a 3000-kw generator each. The second set has a 3000-kw generator for No. 4 stand, a 3200-kw generator for No. 5 stand, and a 500-kw generator for the tension reel. Each set is driven by a 10,000-hp synchronous motor.

Because of special insulation used in the drive motors, they can be operated steadily at as much as 20 per cent overload.

The two independent gear sets on stands No. 3, 4 and 5 are mounted in a common one-piece, cast housing.

This five-stand 42-in. tandem cold mill is of heavy construction. The mill has a maximum delivery speed of 6023 fpm.



Annealing facilities have been expanded by this continuous annealing line designed to operate at speeds up to 2000 fpm.

Gear diameters were held to a minimum and three-bearing construction was used for maximum rigidity.

A recirculating oil system provides lubrication for the back-up rolls, and another serves the drives and screw-down mechanisms. An automatic high pressure system furnishes grease for work roll bearings. Palm oil for the strip in the mill is supplied by a recirculating system.

The tandem mill takes hot rolled, pickled strip 0.075 to 0.100 in. thick up to 38 in. wide and reduces it to a minimum gage of 0.0072 in. It has a monthly capacity of about 53,600 tons, and is capable of delivery speeds up to 6000 fpm, although normal operation is of the order of 4500 fpm.

As a guide in tension control, an indicating tensiometer is located between each pair of stands. Strip gage is maintained by reference to an x-ray gage following the last stand.

After cold rolling, coils are moved by industrial truck to three electrolytic cleaning lines where the oil from the cold rolling process is removed in an electrolytic caustic tank. One of these lines operates at speeds up to 2200 fpm, the other two at 1800 fpm.

The 52-in. diam coils formed at the cleaning lines are up-ended, weighed and taken to the annealing department. Here are 13 rectangular portable annealing covers 21 ft long x 13 ft x 10 in. wide x 8 ft-5 in. high and five cylindrical covers 10 ft 7⅝ in. outside diameter x 14 ft-10⅛ in. high. The rectangular furnaces each take eight stacks of coils totaling about 175 tons. The cylindrical furnaces take a single stack of coils totaling about 40 tons. All furnaces are fired with coke oven gas. Gas and air are proportioned and premixed by a carburetor on each furnace. A deoxidizing atmosphere, supplied by four gas preparation machines, is maintained within the inner covers.

Automatic temperature controls are mounted on each furnace cover and coil temperatures are recorded in a central control room. Fuel consumption averages 750,000 Btu per ton annealed.

Annealing facilities have been expanded recently by the addition of a continuous annealing line, 330 ft long overall, designed to operate at speeds up to 2000 fpm. The line has the usual payoff coil holders, shear, welder, side trimmer, electrolytic cleaner, scrubber, dryer, looping tower, furnace, pin hole detector, hardness gage, shear and winding reels.

The furnace is divided into four sections: heating, soaking, controlled cooling and final cooling. The heating zone is fired with natural gas at a rate of 12,170 cfhr. The soaking zone is heated by 760 kw of electric resistance heaters, with 660 kw more in the controlled cooling zone.

Strip length in the furnace totals 1960 ft, with 370 ft in the heating section, 490 ft in the soaking section, 368 ft in the controlled cooling section and 732 in the final cooling section.

Operating at the maximum speed of 2000 fpm, the furnace heats strip to about 1350 F in 11 sec, soaks it at that temperature for 14.5 sec, allows it to cool to about 900 F in 11 sec, and finally cools it to about 150 F in 22 sec.

The line handles strip up to 38½ in. wide in coils of 85 in. maximum outside diameter, 50,000-lb maximum weight. At maximum speed, it will process 30 tons of strip per hour.

The entry looping tower holds 1250 ft of strip to

avoid delays when successive coils are welded together.

An electronic computor is provided to accumulate data on strip gage, temperature, speed, etc. Ultimately, the computor will be used to regulate temperature and speed.

A thickness gage on the entry end of this line permits the discard of any off-gage material at the head and tail ends of the coil before the strip enters the furnace.

Two 20,000-cfhr gas preparation units provide atmosphere gas to protect the strip surface as it proceeds through the continuous anneal.

Annealed coils go to the temper mills, where a light reduction, or "skin-pass" is made to impart good surface to the strip and bring it to the desired hardness and stiffness. Most of the tonnage is rolled on a two-stand unit which was put into operation in 1951. Both stands are driven by twin motor drives, with the motors on the second stand of double armature design. Table XI gives data on this mill. An unusual feature of this mill is that No. 1 stand is able to use work rolls ranging from 10 to 19 in. in diameter, making the mill very flexible. In No. 1 stand, the back-up rolls are driven, while in No. 2 stand, the work rolls are driven.

The drive motors receive power from a 2000-kw, 600-volt, d-c motor-generator set.

Work rolls in this mill are of forged steel, with those in the first stand having a shot blasted finish and smooth rolls in the second stand.

There are also two single stand temper mills as listed in Table XI. The drive of each of these mills is served by a 500-kw, 250-volt motor-generator set.

Coils may now be shipped as black plate without further processing or they may be taken to the tinning departments. In some cases, coils may require special preparation which is carried out in three coil preparation lines, with side trimmers and welders. Coils may be trimmed to specified width or inspected for shape, surface and hardness.

Tinning is performed either by electroplating or by hot dipping. There are three electrolytic lines, two of the halogen type and one alkaline, (presently being converted to halogen) capable of putting on coating weights of 0.10 to 1.00 lb per base box.

The largest of these lines is 470 ft long overall and operates at speeds up to 1740 fpm. This line contains pay-off reels, shear, welder, looping pit, alkaline cleaner, pickling tank, scrubbers, plating tanks, 1800-kw induction brightening equipment, flying shear and tension reels. Two horizontal plating tanks, each containing 12 plating cells, are located one above the other, and the strip doubles back and forth in horizontal planes as it passes through. Since only one side of the strip is plated in each tank, and since plating current to each cell is individually controlled, the two sides of the strip may be coated with different coating weights. A total of 180,000 amp plating current is available.

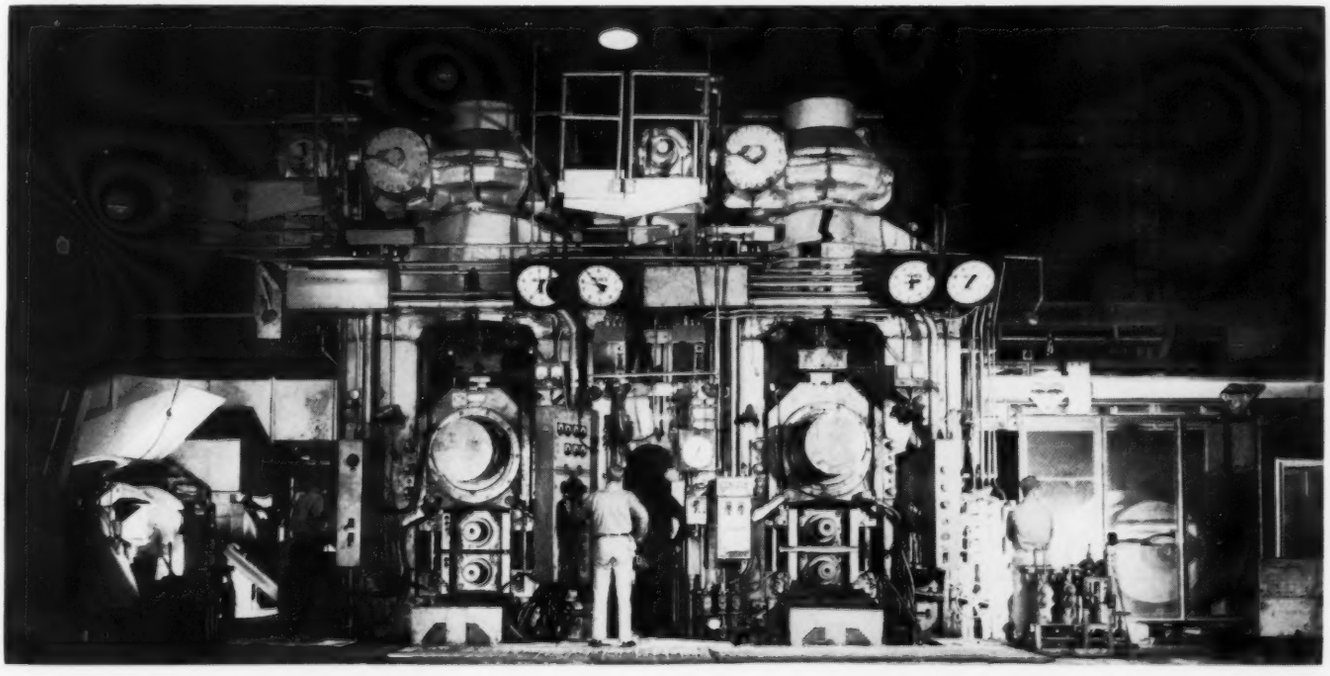
The line now being converted is being installed with 12 plating cells, 120,000-amp plating current and a 2400-kw induction reflow unit. It will operate at 1800 fpm on 0.25-lb coating.

X-ray gages, designed and developed by J&L, are installed on all three electrolytic lines to provide a continuous, accurate check on tin coating thickness.

Total capacity of the electrolytic tinning lines is approximately 45,300 tons per month, with about 75 per cent having a coating weight of 0.25 lb per base box and the balance 0.50 lb, 0.75 lb, 1.00 lb and 1.00/0.25 lb differential lb coatings.

Six rotary flying shear lines are provided to cut up coils, which may be of black plate for shipment of electrolytic tinplate or of black plate intended for hot dip tinning. These units have side trimmers and are equipped with beta-ray thickness gages and pin hole detectors. Sheared tinplate is separated into primes and off-grade material. The latter is taken to the assorting department for further inspection and sorting. Prime electrolytic and black plate product intended for shipment is carried by tractor to the packing conveyor.

This two-stand temper mill, with a maximum delivery speed of 7450 fpm, makes a skin pass on the annealed strip to restore temper and improve surface.



Prime black plate intended for tinning goes to the hot dip tinning department.

This cut-to-length black plate is first given a light pickle in 3 per cent sulphuric acid solution in a four-arm white pickler. It is then moved to one of ten hot-dip tinning machines where coatings of 1.25 to 1.50 lb per base box are applied at speeds up to 500 in. per min. Defective electrolytic plate may also be reclaimed by hot dipping.

Hot dip plate is then assorted, counted and transported to the packing area. Here prime plate is packed on an 88-ft conveyor which travels at 50 fpm. The packed plate is then put into warehouses that will hold 70,000 tons of product. Temperature in these buildings is automatically controlled for protection of the product. From here, the product is shipped out by rail or truck.

METALLURGICAL CONTROL

Quality control from raw materials to finished product is a primary obligation of the metallurgical department. The control function is performed by a staff of more than 200 investigators, observers, inspectors, and technicians who monitor the various phases of plant operations. Observations and trends are highlighted through periodic quality meetings and reports. The main metallurgical building is centrally located in the plant and houses offices, physical testing and metallographic laboratories as well as automatic punched card data processing equipment for statistical analysis of operating and metallurgical information. The physical laboratory contains a machine shop, modern testing equipment and facilities for heat treatment of samples. The metallographic laboratory is equipped for photomicroscopy and photography. Complete chemical laboratory facilities are provided in a separate building nearby.

The requirements and performance of products in the field must be made known to the metallurgical department so that standards can be adjusted as required. This information is developed by metallurgical service engineers who maintain a liaison between customers and the mill. This effort is coordinated at headquarters by the technical services division of the research and development department, which also coordinates metallurgical activities on a company-wide basis.

The Aliquippa metallurgical department is organized in four principal divisions serving the major production areas of the plant: steelworks, tubular products, flat rolled products, and rod and wire products. The steelworks division is responsible for checking and enforcing quality requirements at the blast furnaces, basic oxygen, bessemer, open hearth, and blooming, bar, billet, skelp, and merchant mills. It is this division's job to monitor and control steelmaking details, heating, rolling and surface conditions, discarding, chemical analyses and other characteristics dictated by customer requirements.

The tubular products division is responsible for establishing and maintaining the quality standards of those products made in the seamless, continuous weld, and electric weld pipe mills. This includes setting up steel grades, follow-up on critical processing steps, checking inspection standards and establishing heat treating cycles. They also check product performance properties and conduct development work.

The flat rolled products division covers those products made on the hot strip mill and tin mill. At the hot strip mill rolling and coiling temperatures and surface standards are established and monitored. The tin mill has its own laboratory, including modern chemical facilities under metallurgical supervision. Inspection and physical testing stations in the mill are used to control processes and check tinplate quality. There is constant investigation of production problems and of

Present capacity of the electrolytic tinning lines is about 45,300 tons per month. This will be increased when a new line now under construction goes into operation.

Spectrographic equipment is used to determine the alloying elements in steel.

possibilities of improving processes and product.

The wire products division is organized along the same general lines as the tin mill, with laboratory, inspection, observation and investigational groups. Rod and wire products are tested in accordance with their end use, and a constant check is maintained on cleaning and coating compounds and solutions.

UTILITIES

With full operations, Aliquippa Works uses about 75,000,000 kwhr of electric power per month. About one-fifth of this is generated at 25 cycles in the plant, and the balance is purchased at 60 cycles from the public utility system.

Power is generated in the north and south power houses, which are about two miles apart, but tied together by two transmission lines. In the south power house are two turbogenerators, one rated at 17,000 kw driven by a 12-stage turbine and the other at 10,000 kw driven by a 10-stage turbine. Both turbines are equipped with two-pass surface condensers, with 26,500 sq ft of condensing surface in the large unit and 21,000 sq ft in the small unit. These units generate power at 6900 volts, 25 cycles, and operate at 1500 rpm on 225-psig steam, having a steam rate of 12.5 lb per kwhr. The north power house contains one 20,000-kw, 6900-volt unit, driven by a 14-stage, 1500-rpm turbine operating on 435-psig steam, with a steam rate of 10.5 lb per kwhr. This turbine is equipped with a single-pass surface condenser of 17,800 sq ft surface.

Purchased power enters the plant principally from a 69,000-volt switching station adjacent to the utility company's Hopewell sub-station. From this point there are two 69,000-volt lines, one to the south mills sub-station and one to the north mills sub-station.

The south mills sub-station contains four 20,000-kva, 69,000/6900-volt transformers, from which power is distributed to the tinplate department, rod and wire department, and the south frequency changer. At the north mills sub-station there are five 20,000-kva, 69,000/6900-volt transformers serving the oxygen plant, basic oxygen furnaces, blooming mill, hot strip mill, 14-in. merchant mill. north frequency changer, and the welded tube area.

Distribution of 25-cycle power is entirely by overhead open wire, while 60-cycle power is carried principally by overhead and underground cable. The 69,000-volt lines, however, are open wire.

The 25-cycle and 60-cycle systems are tied together with a 25,000-kw frequency changer, which can operate with power flow in either direction. A 10,000-kw frequency changer in the North Mills can only supply an isolated load.

There are some 50 transformer installations ranging from 500 to 4500 kva throughout the plant, supplying 220 and 440-volt power. Direct current is supplied in various load centers by motor-generator sets, rotary converters, and rectifiers.

Steam for the Aliquippa Plant is generated in three separate boiler plants, each serving the section of the works in which it is located. Table XII gives the principal characteristics of the boilers.

The ten boilers in the by-product house generate steam for the coke plant and for two turbine-driven river pumps located nearby. Coke breeze, burned on traveling grate stokers, is the principal fuel, with coke gas and coal available as auxiliary fuels.

The north mills boiler plant consists of four boiler houses located near the blast furnaces. No. 1, 3 and 4 houses furnish steam for a low pressure system which supplies blowing engines, pumps, fuel atomizing, heating, etc. No. 5 house provides steam for the four turboblowers and the 20,000-kw turbogenerator, as well as, through a pressure-reducing desuperheating unit, make-up steam for the low pressure system. No. 1 house uses blast furnace gas direct from the dust catchers, while No. 3, 4 and 5 houses receive partially cleaned hot gas. Powdered coal for No. 5 house is supplied by a bin system from two ball mills, each of 15 tons per hr capacity.

Treated water is supplied to the boilers at the by-product and north mill houses from a hot process lime-soda softener. Make-up water is 100 per cent for all of these boilers except No. 5 house, where condensate from the turbines reduce make-up to 50 per cent.

At the south mills there are three boiler houses located south of the tin mill. The boilers in the waste heat house originally recovered waste heat from old rectangular coke ovens, but since use of these ovens has been discontinued, the boilers are fired with heavy fuel oil. Steam from these boilers and from the tin mill house flows into a low pressure system which serves process requirements, heating, etc., in the tin mill, wire mill and tube mills. Boilers in No. 3 house are fired with pow-

TABLE XII
Boiler Data

	By-product boiler house			North Mills Boiler Plant					South Mills Boiler Plant		
				No. 1 house	No. 3 house	No. 4 house	No. 5 house		Tin mill	Waste heat	No. 3 house
No. of boilers → Type →	7 Horizontal tube	2 Bent tube	1 Bent tube	11 Bent tube	10 Bent tube	3 Horizontal tube	2 Horizontal tube	1 Horizontal tube	12 Bent tube	2 Horizontal tube	5 Bent tube
Nominal rating, boiler hp	509	909	834	397	397	1,475	2,494	2,912	397	1,530	1,969
Usual per cent of rating	165	220	275	115	115	205	325	500	120	130	255
Capacity, lb per hr	25,000	60,000	68,000	15,000	15,000	90,000	225,000	400,000	15,000	60,000	150,000
Efficiency, per cent	60	60	75	47	50	70	80	80	50	70	75
Pressure, psig	190	190	190	150	150	170	435	435	150	150	225
Temperature, F	510	510	510	Saturated	Saturated	525	700	700	410	500	525
Boiler surface, sq ft	5,087	8,200	7,115	3,970	3,970	14,750	24,940	24,857	3,970	15,300	19,690
Water wall surface, sq ft	...	887	1,228	...	...	...	...	4,263	...	...	...
Superheater surface, sq ft	552	587	879	...	...	1,378	3,756	3,945	200	2,650	1,798
Air heater surface, sq ft	...	...	...	...	...	...	28,600	40,750	...	...	...
Combustion volume, cu ft	981	3,990	2,430	1,500	1,500	4,172	22,500	25,836	509	1,350	10,350
Kind of fuel	Coke breeze, Coke gas	Coke breeze, Coke gas, Coal	Coal, Coke gas	Blast furnace gas	Blast furnace gas	Blast furnace gas	Blast furnace gas, Powdered coal	Blast furnace gas, Powdered coal	Bunker fuel oil	Bunker fuel oil	Powdered coal, Coke gas

dered coal from unit pulverizers, with coke oven gas as an auxiliary. Steam from these boilers is used in the two turbogenerators and as make-up for the low pressure system.

The south mills boilers receive treated water from an intermittent cold process lime-soda softener. No. 3 house, which gets condensate from the turbines, operates with 50 per cent make-up, while the other houses use 100 per cent make-up.

Water consumption of the Aliquippa plant averages 315,000,000 gal per day—more than 50,000 gal per ton of steel made. Water is pumped from the Ohio River at three pumping stations, passing through trash, racks and revolving screens. All river water is intermittently chlorinated.

The north pump house contains three pumps, one rated at 60,000,000 gal per day, one at 30,000,000 gal per day, and one at 40,000,000 gal per day. The first two are turbine-driven, the last motor-driven. This house is connected to a large stand pipe by a 48-in. main. The north house furnishes water to the coke plant, blast furnaces, steel works and rolling mills.

The central pump house is also connected to the above mentioned stand pipe by a 60-in. main. This pump house contains five 15,000,000-gal-per-day pumps and two 40,000,000-gal-per-day pumps. These pumps help to supply the needs of the north mills, the strip mill and the tube mill area. The five small pumps are driven with 25-cycle motors, and the two large pumps are driven with 60-cycle motors.

Water for the tin mill, rod mill and wire mill comes from the south pump house, which contains two 40,000,000-gal-per-day motor-driven pumps and one turbine-driven pump of 10,000,000-gal-per-day capacity. There are also three low-head condenser pumps in this pump house. These pumps are motor driven and supply water only to the surface condensers at the power house.

In addition to the two water softening plants serving the boilers, other treating plants provide water for special processes. Water for cooling rolls of the tinplate cold reduction mill is processed through 18 sand bed filters. Extremely clean, pure water is supplied to the electrolytic tinning lines by a 750-gpm demineralizing plant. In addition, clarified water is obtained from two large reactors in this plant.

With full operations, monthly fuel requirements of the Aliquippa plant, over and above the coke oven gas, blast furnace gas and coke breeze produced in the plant, consist approximately of 37,000 tons of steam coal, 1,600,000 gal of heavy fuel oil, and 500,000,000 cu ft of natural gas. Natural gas to the extent of 400,000 cfhr, stabilized with air, can be introduced into the coke gas line as required. Also, natural gas may be used directly on certain furnaces as a stand-by fuel when desired.

SERVICE DEPARTMENTS

To accommodate river barge shipments of products, a modern dock is located at the extreme south end of the plant. The wharf, 300 ft long, is constructed of steel sheet piling and has ten mooring cylinders and three ice-breaker cylinders. Part of the dock is covered by a building 150 x 138 ft, served by a 15-ton crane. Two railroad tracks pass through the building, so that material can be handled by crane directly from gondola cars to barges. Material from box cars can be moved by lift trucks to the loading platform, then handled by crane into barges.

The company's traffic and transportation division operates six river towboats and a great many barges of various types.

Railroad traffic is handled partially by plant equipment and trackage, partially by the Aliquippa and Southern Railroad. The plant has 36 miles of standard gage track, the A&S, 45 miles. All locomotives are diesel-electric. There is also a small stretch of narrow gage track between the open hearth and blooming mill, handling ingot buggies.

All maintenance and a considerable portion of the construction work at Aliquippa are handled through an extensive shop system. There are five complete machine shops containing various sized lathes, planers, shapers, boring mills, milling machines, gear cutters, drill presses, slotters, grinders, etc. The largest shop, the general machine shop, is located in the north mill area and does work for all mills. A forge and blacksmith shop adjoins this machine shop. The south mill shop and the tin mill shop do work for the tin mill and the rod and wire department. The seamless tube and welded tube departments each have their own shop.

All plate fabrication and welding, as well as most of the boiler repair work, is handled by the boiler shop. Motor repair work is done by the electrical shop, and a line and wire gang maintains the electrical distribution system and does a major part of the electrical construction work.

There is also a tin shop, a carpenter shop, a paint shop and a pipe shop, all equipped to carry out their respective crafts as called for by maintenance and construction programs. ▲

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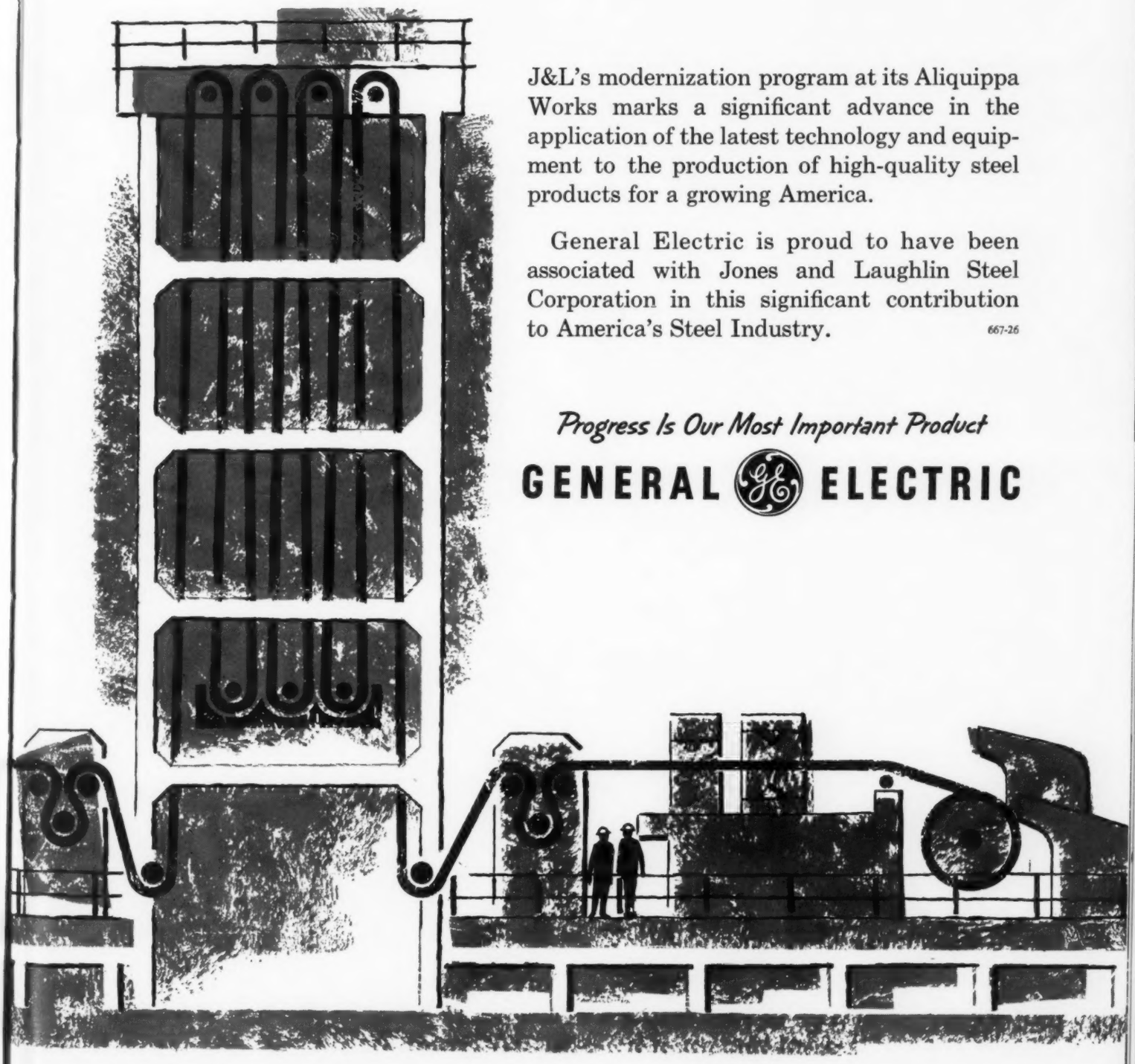

J&L's modernization program at its Aliquippa Works marks a significant advance in the application of the latest technology and equipment to the production of high-quality steel products for a growing America.

General Electric is proud to have been associated with Jones and Laughlin Steel Corporation in this significant contribution to America's Steel Industry. 667-26

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MESTA 44" Slabbing-Blooming Mill

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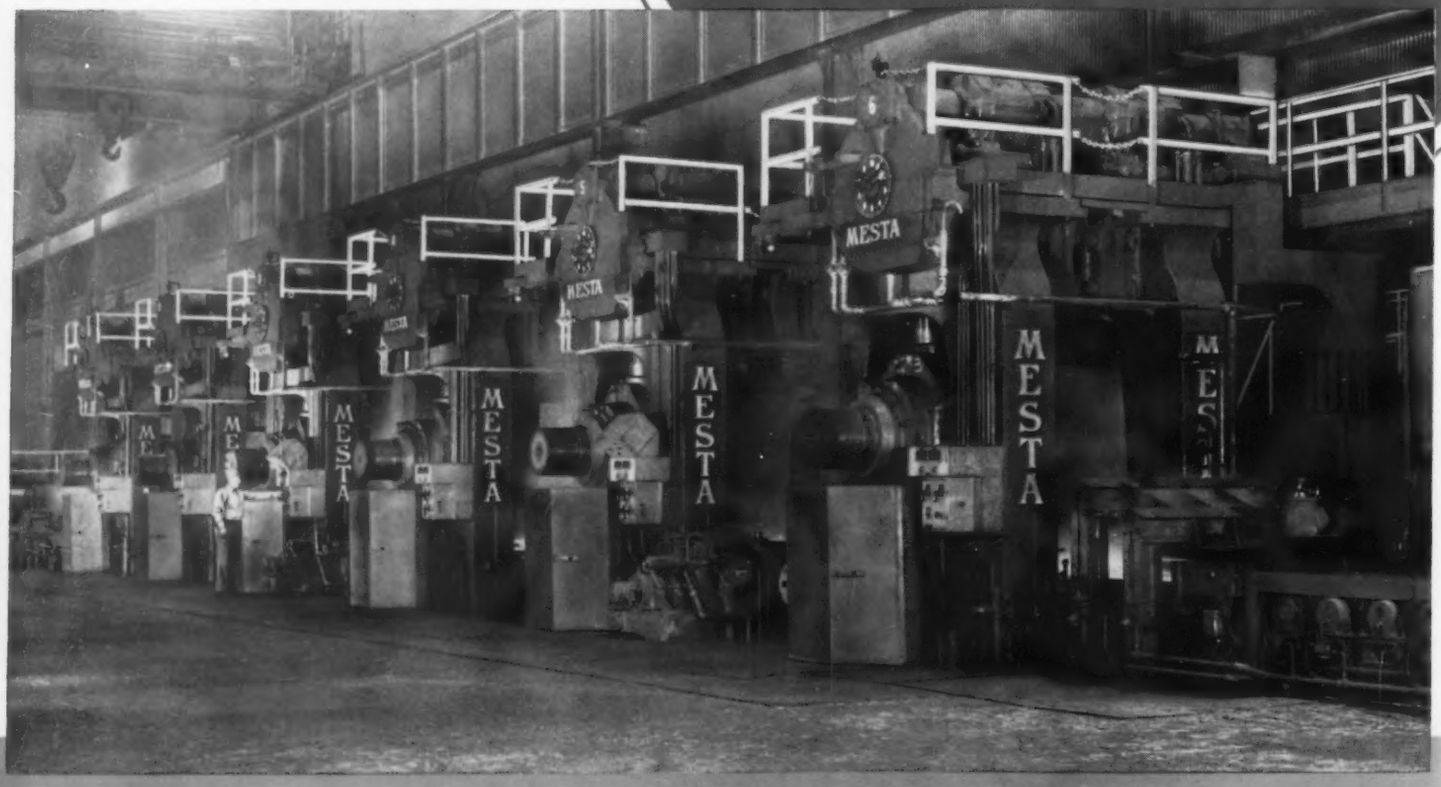
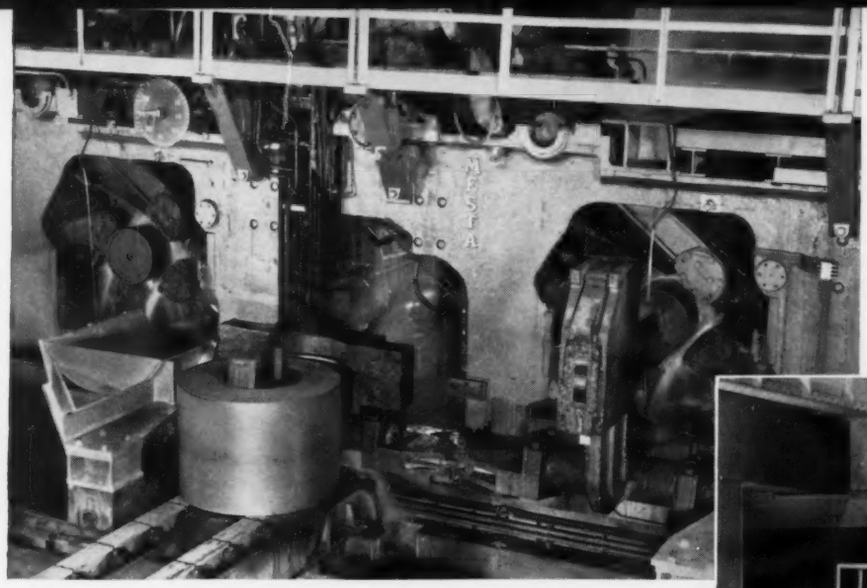


MESTA 44" Four-High Hot Strip Mill Finishing Stands with three Finishing Vertical Edging Mills



MESTA Hot Strip Down-Coilers with rotating and expanding mandrels

MESTA 44" Universal Reversing Roughing Mill and Vertical Edging Mill

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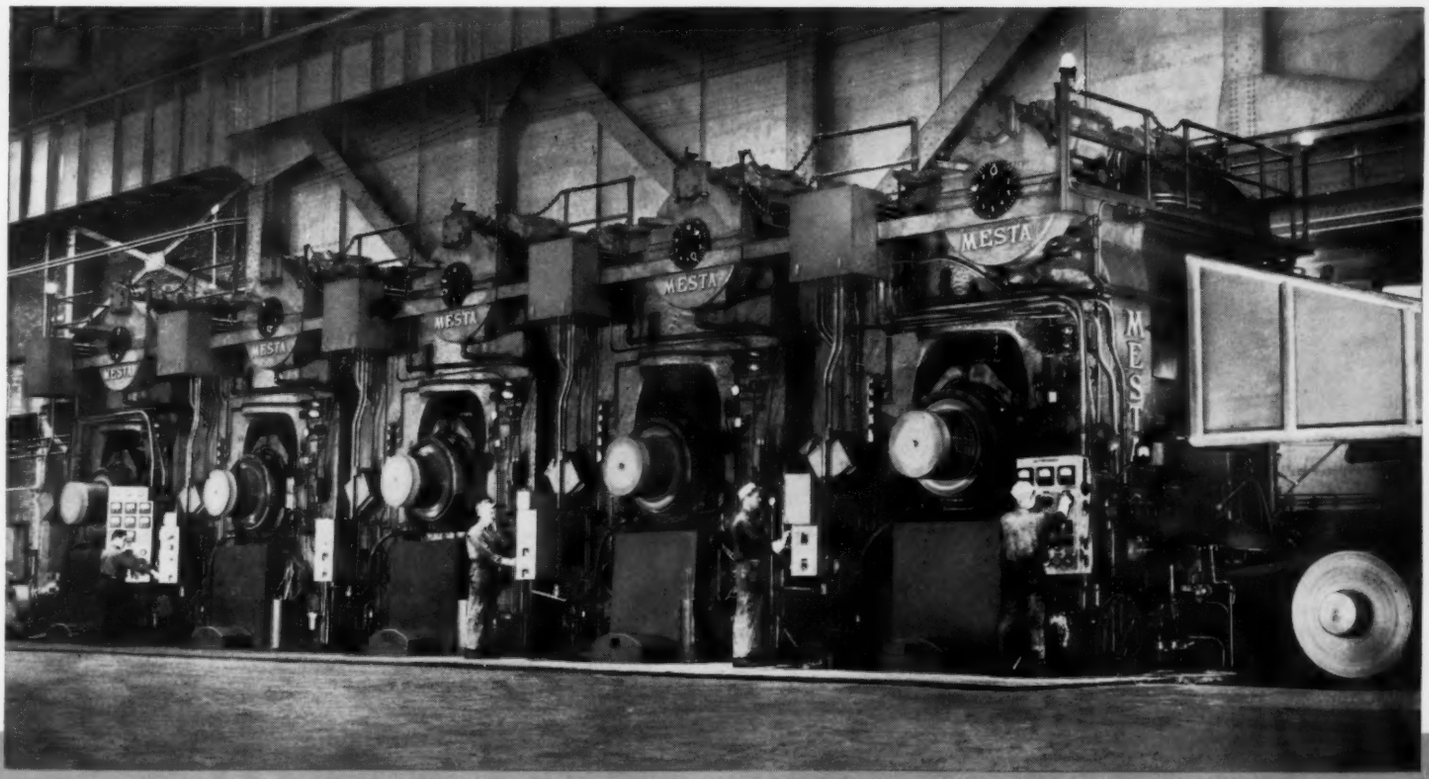


Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Jones & Laughlin Expands Pipe and Tube Capacity

NINE NEW SUTTON STRAIGHTENERS ARE INSTALLED AT J&L ALIQUIPPA WORKS

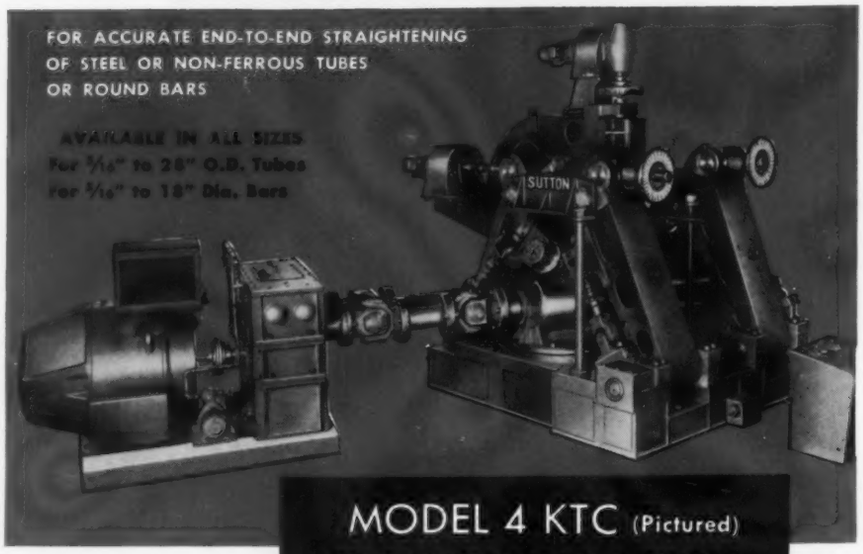
A Model 4KTC Modified, Sutton 7-Roll Straightener has been installed in Jones & Laughlin's new electric weld pipe mill at the J&L Aliquippa Works. Complete with entry and delivery tables, the new Sutton machine is used to straighten 4½" to 12¾" O.D. electric weld pipe at high production speeds.

Previously, a Model 4KTC Sutton 7-Roll Straightener (as pictured at right) was selected by J&L for the seamless tube mill as the best machine available to straighten heat-treated oil country tubular products of from 4½" to 9⅝" O.D. in 16 to 50 foot lengths with both plain and upset ends. Another Sutton Model 3½KTC is in use in the seamless tube mill for straightening plain and external-upset tubing and J&L integral joint tubing. All of the Sutton 7-Roll machines feature quality guideless straightening at high speeds with a minimum of time required for size changes.

Six additional Sutton straighteners have been installed for Jones & Laughlin at Aliquippa. In the No. 1 Continuous Weld Pipe mill, two No. 2JM Special High-Speed Straighteners are incorporated directly in the mill line for ½" to 1½" pipe. With operating speeds up to 900 feet per minute they are able to handle the full mill production. A third No. 2JM Special High-Speed Straightener is being used at this mill for job lot straightening. On the No. 2 Continuous Weld Pipe Mill, two Sutton 2JM Modified High-Speed Pipe Straighteners have been installed directly in the mill line for operation at speeds up to 500 feet per minute to handle full mill production of 1¼" to 4" pipe. Also, at this mill, a Model 2J Modified Pipe Straightener is being used to straighten 2" to 6" galvanized pipe.

All of the straighteners installed at the J&L Aliquippa Works are standard or modifications of standard Sutton straighteners.

SUTTON 7-Roll STRAIGHTENERS


FOR ACCURATE END-TO-END STRAIGHTENING
OF STEEL OR NON-FERROUS TUBES
OR ROUND BARS
AVAILABLE IN ALL SIZES
For ⅜" to 28" O.D. Tubes
For ⅜" to 18" Dia. Bars
SUTTON

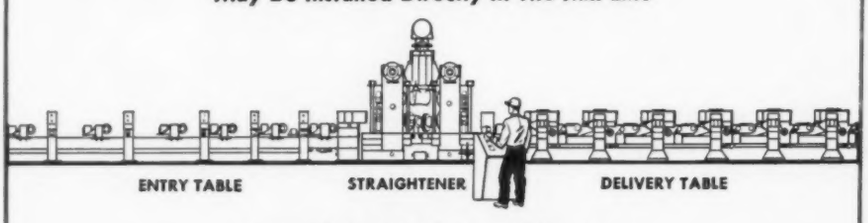
MODEL 4 KTC (Pictured)
TUBES FROM 3⅝" O.D. to 12" O.D.
BARS FROM 3⅝" to 7½" Dia.

Sutton seven-roll straighteners are the finest available. Patented cluster roll arrangement positively confines work to pass line from entry to delivery without guides. Roll angles are automatically adjusted to proper setting with full contact between work and rolls.

STRAIGHTENS EXTERNAL UPSET TUBING, CASING and DRILL PIPE 20 to 50 Times Faster!

- TRULY GUIDELESS
- HIGH PRODUCTION
- QUALITY STRAIGHTENING

SUTTON ENGINEERED STRAIGHTENING
May Be Installed Directly In The Mill Line



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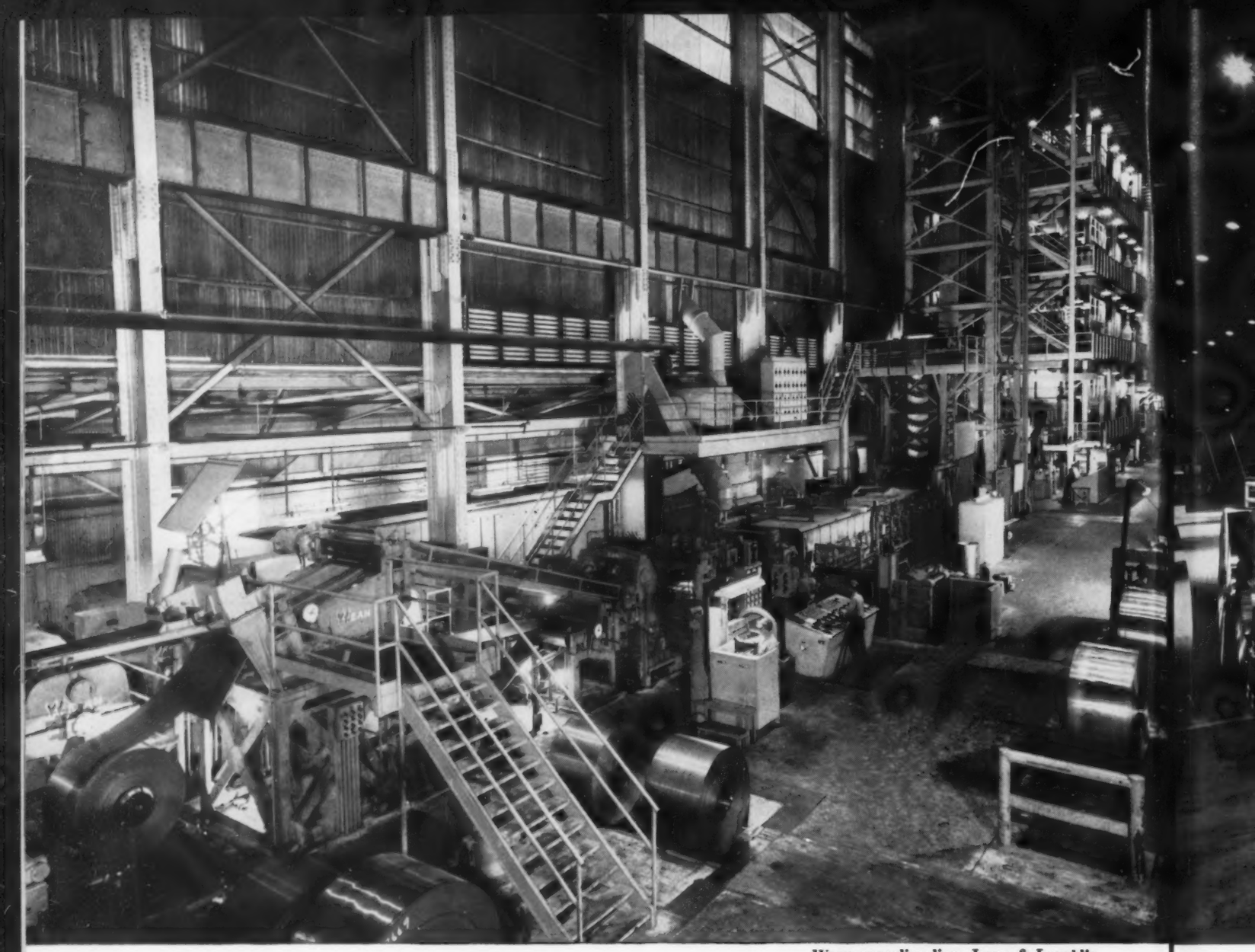

Wean annealing line, Jones & Laughlin Steel Corporation, Aliquippa works.

J & L completes major with two new

These modern Wean lines installed at Jones & Laughlin's Aliquippa plant are evidence of J&L's investment in providing its customers with a growing supply of modern, high-quality tin plate.

The precision-engineered, high-speed Wean tin plate annealing line can handle 50,000 lb coils, with a maximum O.D. of 85". Six precision bridles, coupled with other design features, maintain constant tension and accurate tracking of the strip.

A new Wean tinning line presently being installed at J&L (similar to the one illustrated at right) will employ the horizontal acid (Halogen) plating process and induction reflow

Wean electrolytic tinning line, Jones & Laughlin Steel Corporation, Aliquippa works.

tin plate expansion Wean Processing Lines

brightening. This line, the third Wean line of its type at Aliquippa, will be capable of producing tin plate at speeds up to 2000 fpm. Processing a range of gauges from .0055" to .025", it can handle 40,000 lb coils up to 70" O.D., with maximum width of 42".

Both lines indicate the continued confidence of Jones & Laughlin in Wean "creative engineering." Wean Engineering has supplied more electrolytic tinning facilities to the major steel producers of the world than all other equipment manufacturers combined. Why not draw upon this outstanding experience in planning expansion or modernization of your tin plate facilities?

THE WEAN ENGINEERING COMPANY, INC. • WARREN, OHIO

Spraying Systems spray nozzle installation on Jones & Laughlin Aliquippa Works finishing mill backup rolls.

Sheet cooling with Spraying Systems spray nozzles on Aliquippa Works hot strip mill run-out tables.

SPRAY NOZZLES

for descaling • oxygen process gas cooling • pig—ingot mold—slab and hot strip cooling • roll cooling • cooling open hearth regenerators • lubricant spraying • blast furnace gas washing and cooling and related applications

Proved by performance

At the Jones & Laughlin Aliquippa Works and in steel mills throughout the country, Spraying Systems Spray Nozzles have proved themselves outstanding . . . wherever spraying is applied in steelmaking. Designed in a wide choice of types and capacities to provide a full range of spray characteristics and dependable, trouble-free performance.

Large spray nozzle stocks are carried to assure prompt delivery. Sales offices are located in all steel mill areas for immediate service. Your local Spraying Systems representative will be happy to give you complete information to meet any spraying need. Your inquiry is cordially invited.

For spray nozzle reference information, write for Catalog 24 . . and special data sheets on "Steel Mill Applications."

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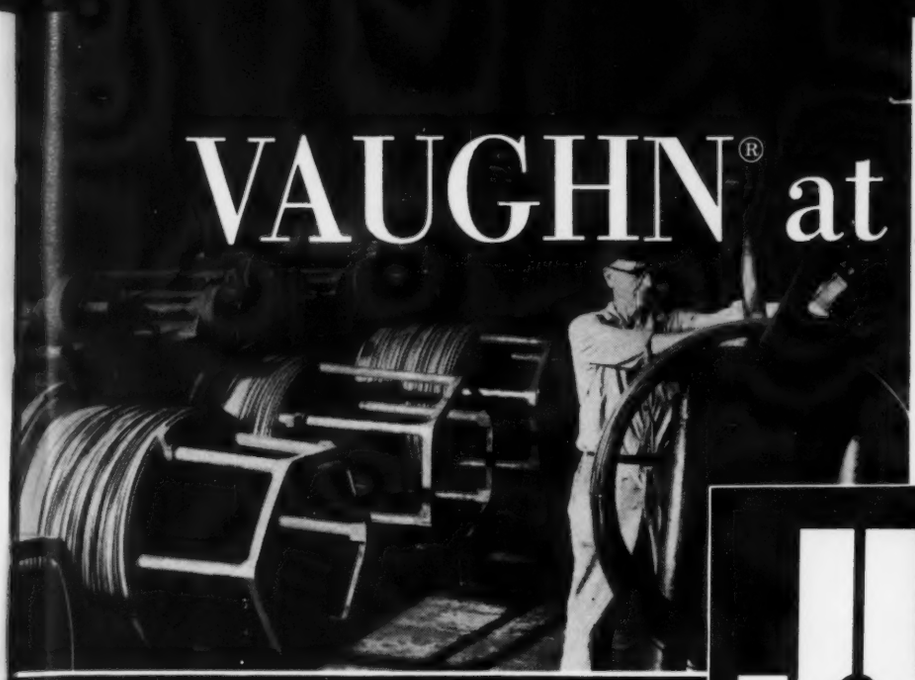
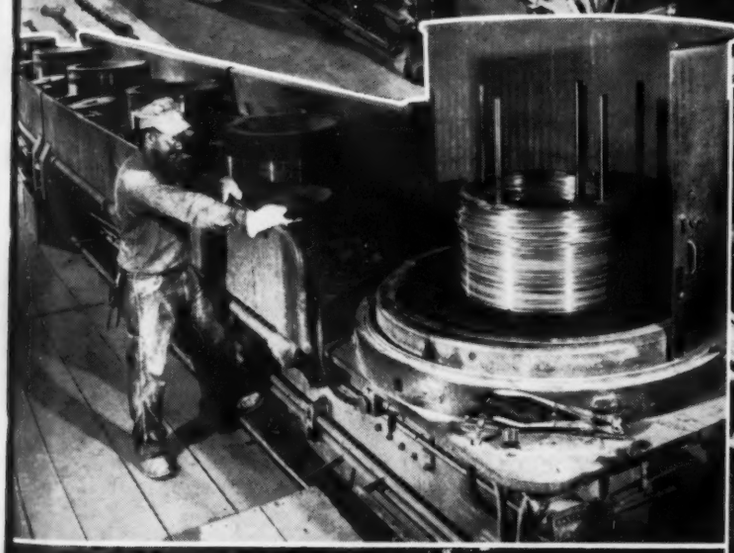
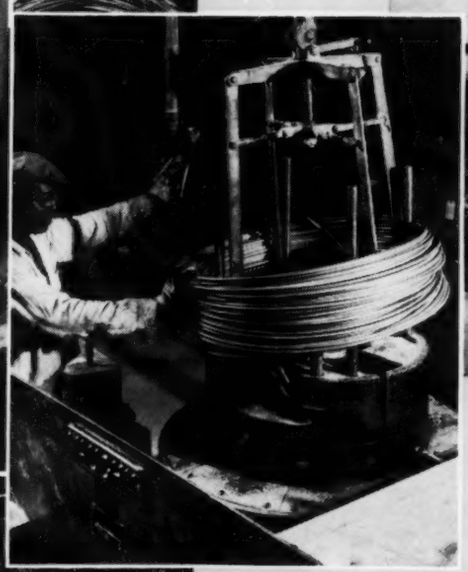
VAUGHN® at Aliquippa

MODERN EQUIPMENT FOR FINER AND FASTER WIRE PRODUCTION







Typical of J & L modernization at the Aliquippa plant are the many Vaughn wire drawing machines installed at that location over the past 5 years. These Vaughn units bring the latest advances in speed, safety and operating ease to the production of top quality J & L wire—joining the ranks of dependable Vaughn equipment at Aliquippa performing so faithfully over the years.

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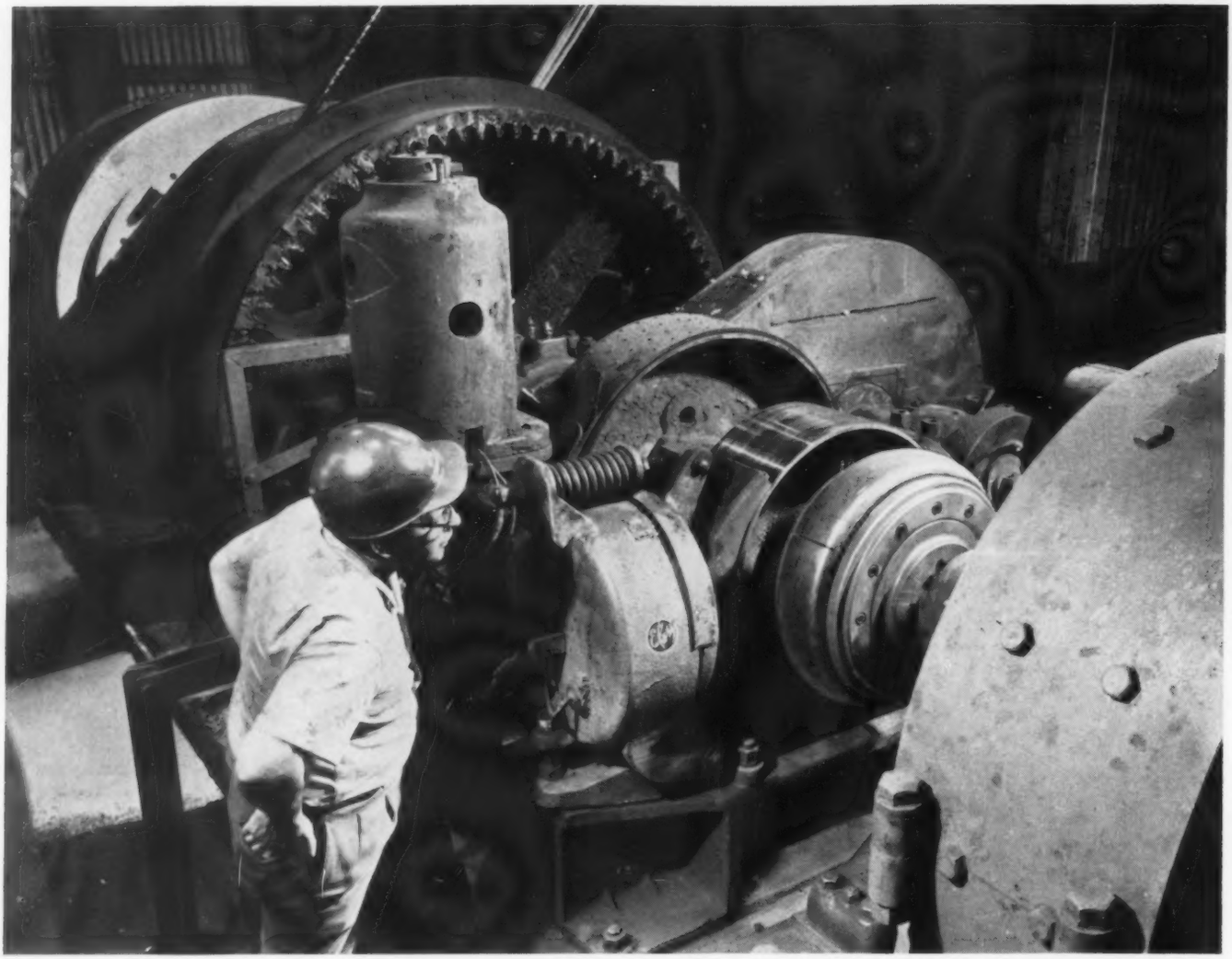
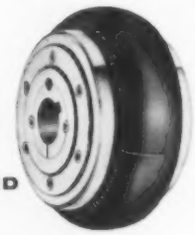


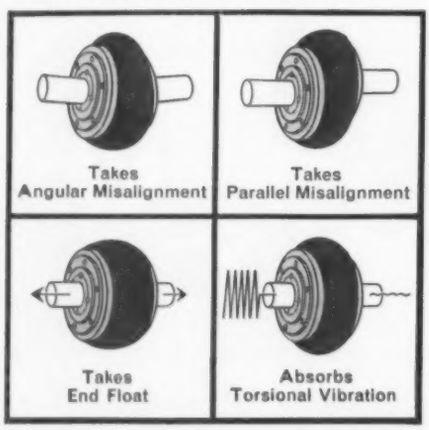
Blast Furnace Skip Hoist Drive—Jones & Laughlin Aliquippa Works

New idea in couplings solves shock problem in J & L skip hoist drive



STANDARD TYPE

THE COUPLING WITH THE 4-WAY FLEX



Shock meets its master in the remarkable flexing characteristics of the Dodge Para-flex Coupling. The tire-like element of this tough, remarkable coupling absorbs terrific punishment in this skip hoist, operating in 1-minute cycles. The skip car has a capacity of 122 cu. ft. It is driven by a 250 hp, 600 rpm motor. Shafts are 5″. Instant stops, controlled by a brake with 12″ drum face, impose powerful shock loads.

Dodge Para-flex flexible cushion couplings "swallow up" misalignment. They fit themselves to changing shaft conditions—angular, parallel, end float or any combination of all three! They absorb vibration and shock loads.

Standard Type available in capacities up to 2000 hp at 1080 rpm. High Speed and Flywheel Types are also available. Write for bulletin.

DODGE MANUFACTURING CORPORATION, 5900 Union Street, Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under Dodge "Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Equipment."

TRANTINYL

GUIDES THE STEEL INDUSTRY

Mill Guides

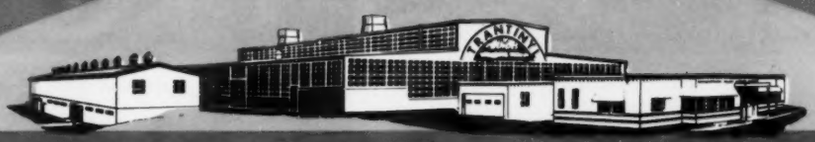
used by J&L STEEL

in 44" strip mill
at Aliquippa Works

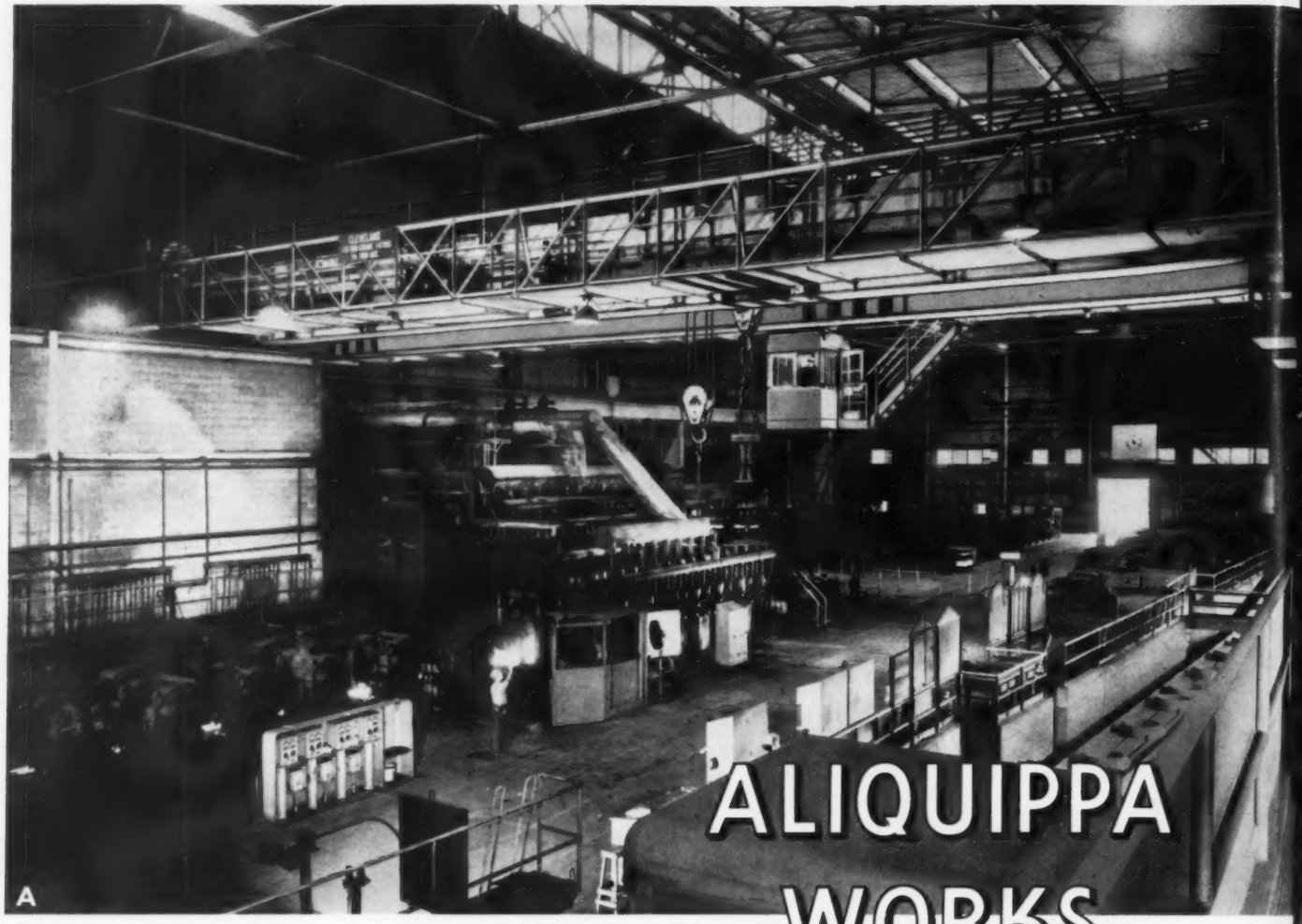
"TRANTINYL" Service to Leading Steel Companies ... continuous for a quarter-century

Youngstown Alloy Casting Corporation
Youngstown, Ohio

Guides for Rolling Mills • Tube Mills • Straightening Machine Guides



Sole Licensee to cast "TRANTINYL" for the Mid-West, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

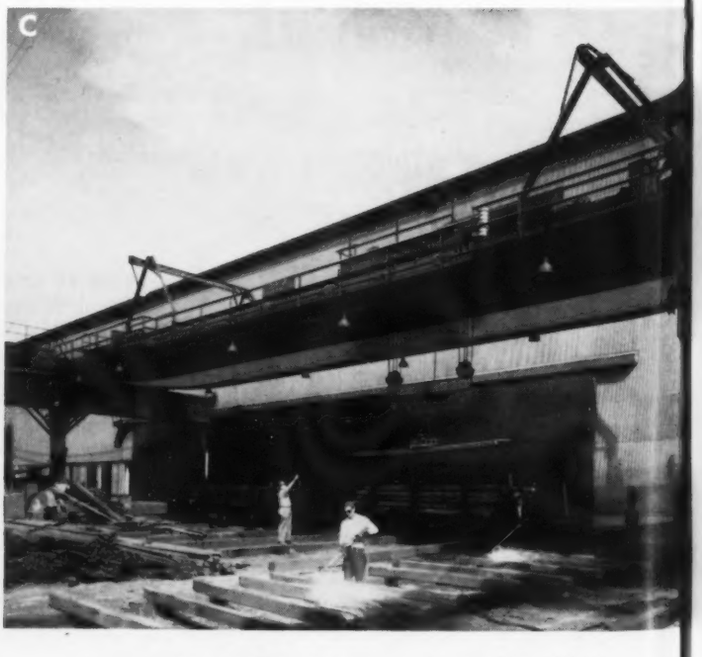


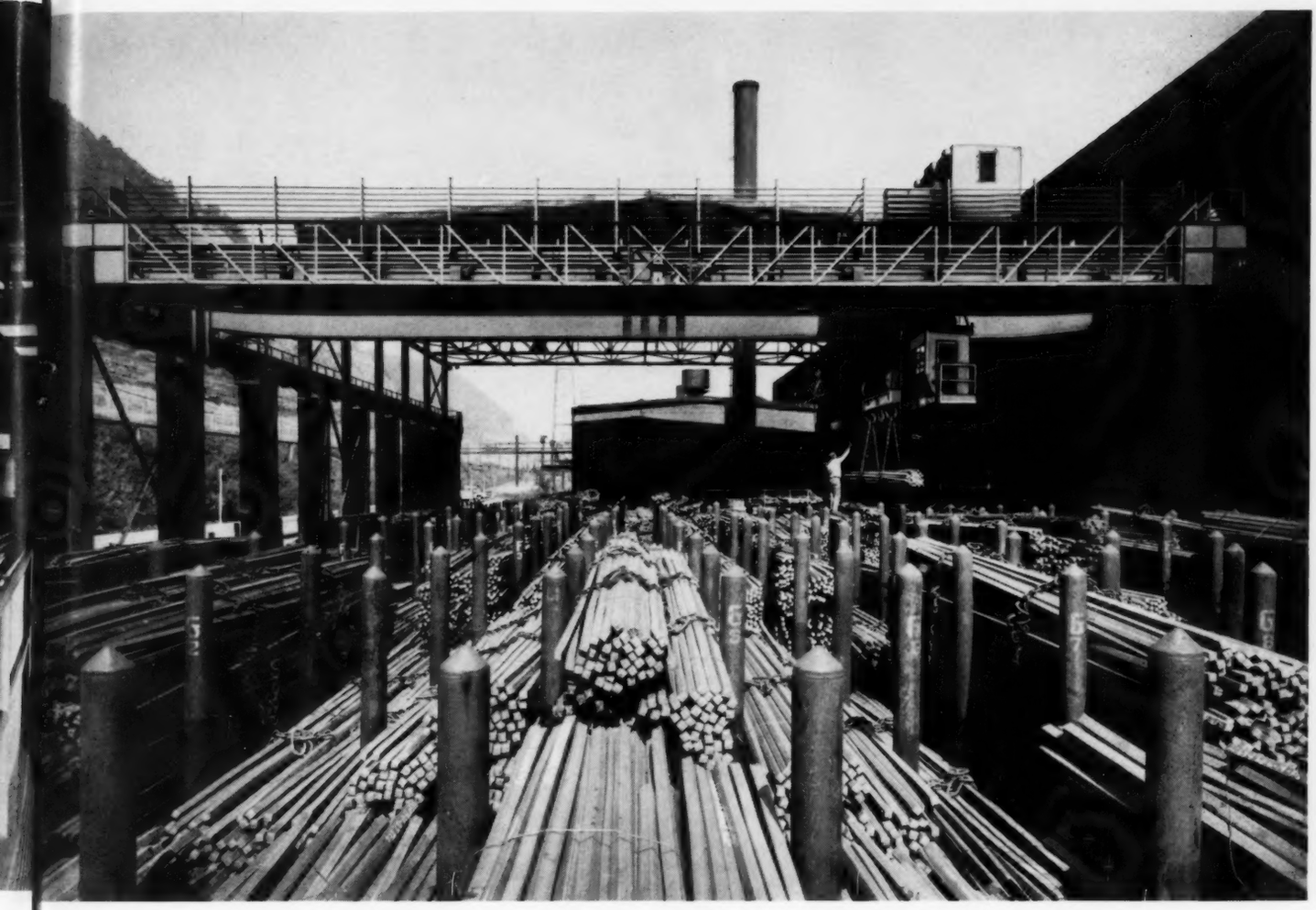
ALIQUIPPA WORKS Served By

A — 15 ton main hoist, 7½ ton auxiliary hoist, 117'-9" span Cleveland Crane serving Rod Mill. Cab located at middle of bridge.

B — 15 ton, 103'-9" span crane in Billet Conditioning Yard. Cab built onto and travels with trolley.

C — Blooming Mill Conditioning Area. 15 ton, 120'-0" span crane operates 20 work shifts a week. Magnet handles ingots, billets, slabs and blooms for scarfing.





24,000 ton capacity Billet Yard served by 15 ton, 103'-9" span crane operating 24 hours a day.

CLEVELAND CRANES FOR OVER 50 YEARS

More than 100 Cleveland Cranes of various capacities and spans have been supplied to Jones & Laughlin Steel Corporation's Aliquippa Works during the past half century.

Despite frequent expansions and improvements involving changes in buildings and plant arrangement, most of these cranes are still in service.

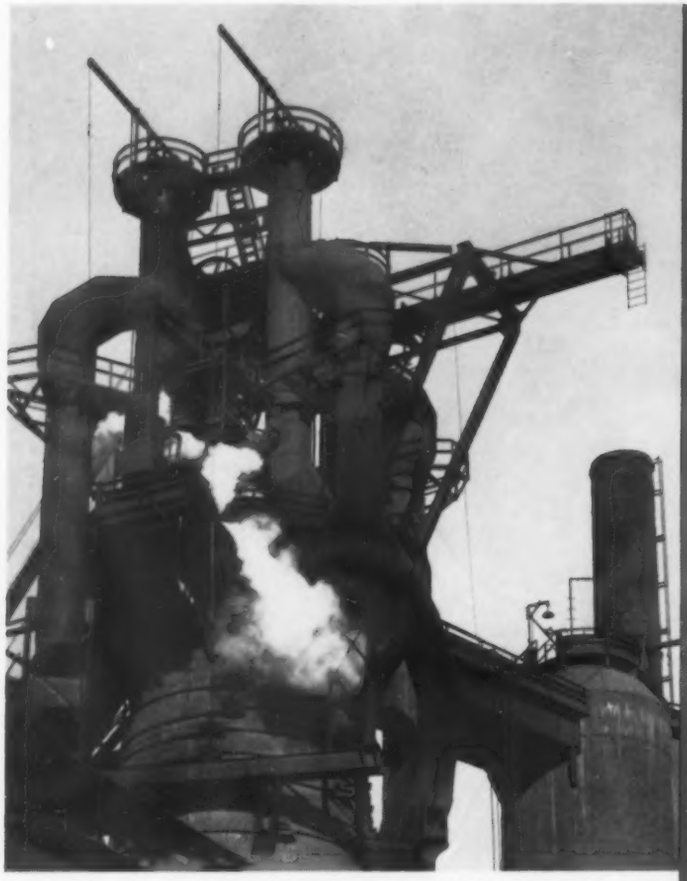
The outstanding record for dependability that Cleveland Cranes have throughout the steel industry holds true for those at J & L. They handle their work smoothly and efficiently year in and year out — operating 8, 16 and 24 hours a day — with minimum maintenance.

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

THE CLEVELAND CRANE & ENGINEERING CO.
5031 EAST 289th STREET • WICKLIFFE, OHIO

Many of J & L's Cleveland Cranes have wide girder spread to facilitate handling. This one has 15 ton main hoist and 7½ ton auxiliary hoist and is provided with three-hook spreader beam.



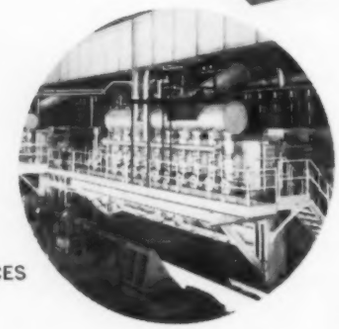
BLAST FURNACE & STOVES

At J & L's ALIQUIPPA WORKS and throughout the steel industry.... A. P. GREEN REFRACTORIES ARE ON THE JOB

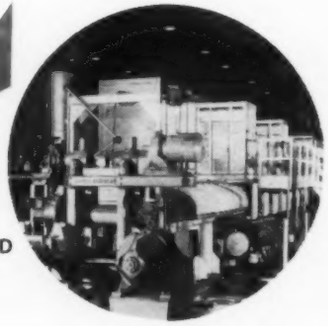
For many years, Jones & Laughlin has used A. P. Green refractories in various types of iron and steel making operations and has found them to be highly satisfactory. The Green Company is pleased to have had a part in the expansion of the great Aliquippa Works of Jones & Laughlin Steel Corp.

A. P. Green manufactures a complete line of highest quality refractories for all phases of iron and steel plant production. Developed and improved over the years to increase lining life and reduce refractory costs in the Steel Industry, A. P. Green refractories are specified by the leading steel companies.

BAR FURNACE



SLAB HEATING FURNACES



CONTINUOUS WELD FURNACE

For detailed information on service and specific recommendations—contact your local A. P. Green representative or write

A. P. GREEN FIRE BRICK COMPANY
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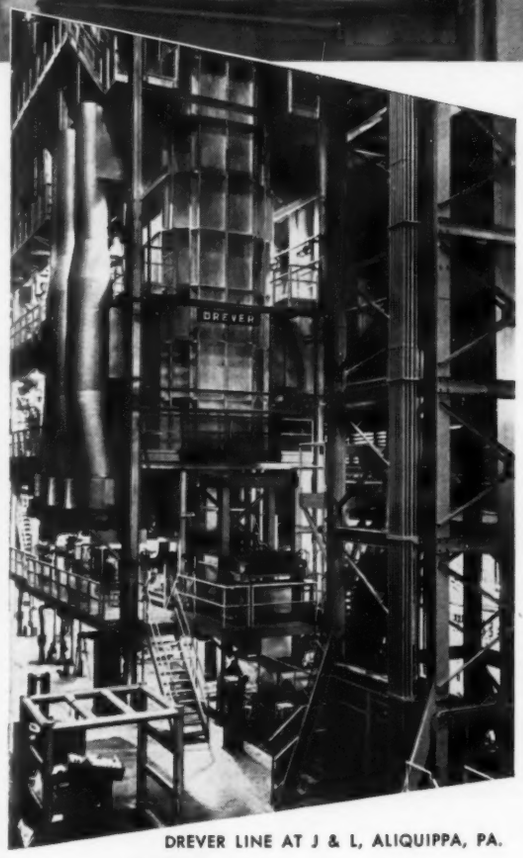


DREVER LINE AT J & L, ALIQUIPPA, PA.

NOT "INDIAN TALK"— JUST A CRYPTIC DESCRIPTION OF THE DREVER "CONVECOOL" SYSTEM FOR ANNEALING LINES

In an uncomplicated design of Plenums (1), Slotted Blast Vents (2), Side Suction Chambers and Ducts (3), (4); with a minimum of Heat Exchangers (5), and Blowers (6); the "Convecool" Convection Cooling System used in Drever Strip Annealing Lines embodies extraordinary engineering ingenuity.

MAXIMUM COOLING EFFICIENCY—MAXIMUM MAINTENANCE ACCESSIBILITY

"Convecool" provides greater cooling atmosphere contact with the strip in a balanced design that can only fail safe without product spoilage or equipment damage. In contrast with complex water systems or multiple motor-blower-heat exchanger arrangements, the "Convecool" unit utilizes a modicum of moving parts in a simplified design that allows immediate, complete accessibility for maintenance or quick repair. Now in operation at the Aliquippa Works of Jones & Laughlin Steel Corp., the "Convecool" section of the Drever Annealing Line can handle strip up to 2000 fpm. At 1000 fpm strip is cooled from 900°F to 150°F in 43 seconds.

DREVER ENGINEERING FOR YOU

Achieving a desired effect with such simplicity of design and operation takes advanced engineering. Just such engineering is necessary to meet today's demand for higher production with more exacting quality standards at lower operating cost. Our engineers are available for consultation concerning your requirements. Write or phone us. Drever Company, Bethayres, Pa. Phone: Wilson 7-3400.

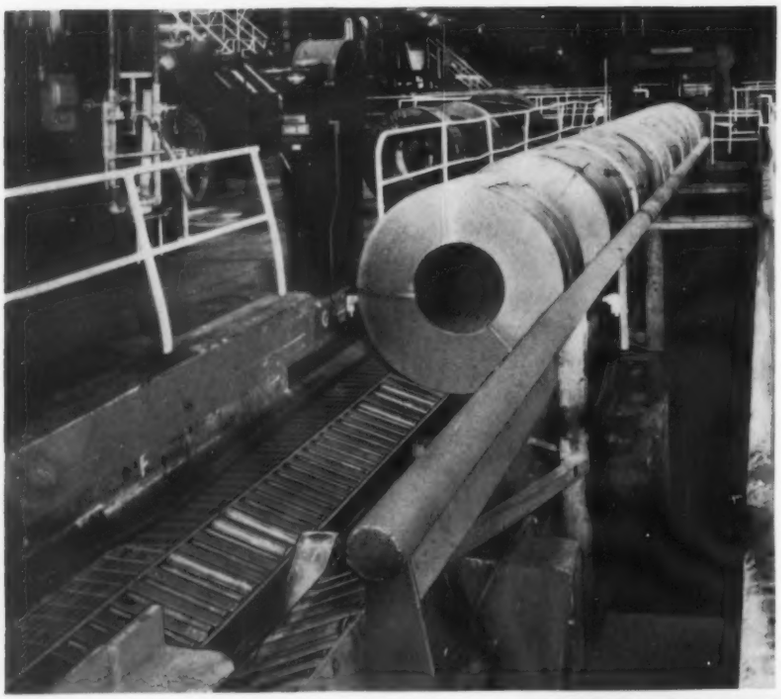
DREVER INDUSTRIAL FURNACES

ENGINEERED TO YOUR PARTICULAR REQUIREMENTS

ENGINEERING AND MANUFACTURING FACILITIES AROUND THE WORLD THROUGH ASSOCIATES IN FRANCE, GREAT BRITAIN, GERMANY, ITALY AND JAPAN

MATHEWS CONVEYERS-

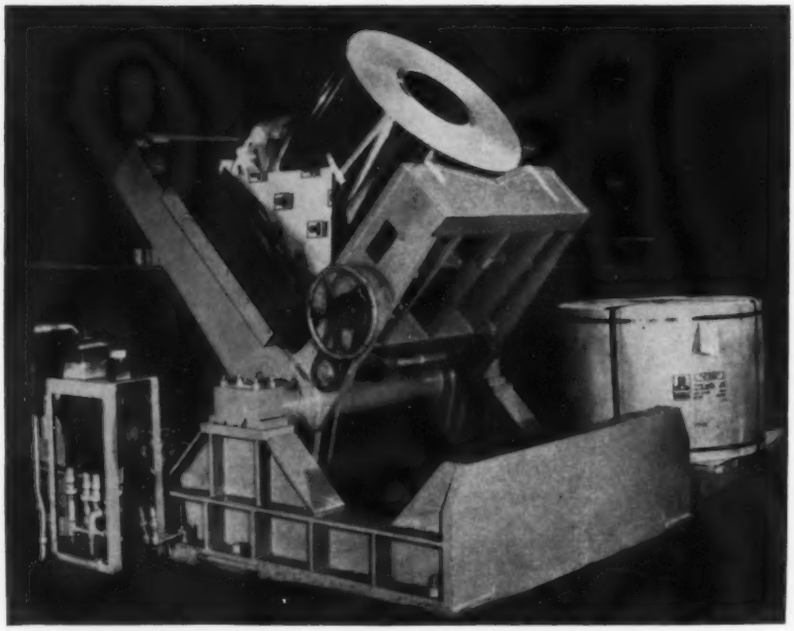
ENGINEERED TO DELIVER OUTSTANDING PERFORMANCE AT



J&L STEEL

At Jones & Laughlin's modern Aliquippa Works, Mathews Pallet Conveyers and Belt Conveyers are helping to create a continuous flow of materials in their new electroweld department. Like all Mathews equipment for the steel industry, these conveyers are built to deliver outstanding performance.

• A 71-foot-long Reciprocating Beam Conveyer designed to handle 36,000-pound coils at the entry end of mill.
(Photo courtesy Aetna-Standard Division, Blaw-Knox Company.)



• Upender handling 20,000-pound tin plate coils. This unit is loaded by ram tractor and unloaded by fork tractor.

MATHEWS CONVEYER COMPANY

GENERAL OFFICES . . . . . ELLWOOD CITY, PENNSYLVANIA
PACIFIC COAST DIV. . . . MATHEWS CONVEYER COMPANY WEST COAST, SAN CARLOS, CALIFORNIA
CANADIAN DIVISION . MATHEWS CONVEYER COMPANY, LTD., PORT HOPE, ONTARIO.

MATHEWS

Over Fifty Years of Leadership in Mechanized Handling

JONES & LAUGHLIN STEEL CORP.

ALIQUIPPA WORKS

PATTERSON—EMERSON—COMSTOCK, INC.

ACTING AS SUB-CONTRACTOR TO THE AETNA - STANDARD DIVISION OF THE BLAW - KNOX COMPANY FURNISHED THE INSTALLATION ENGINEERING AND CONSTRUCTION SERVICES REQUIRED FOR THESE IMPORTANT PRODUCTION FACILITIES:

No. 1 Continuous Buttweld Pipe Mill—$^{1}/_{2}$" to $1^{1}/_{2}$"

No. 2 Continuous Buttweld Pipe Mill—$1^{1}/_{4}$" to 4"

Stretch Reducing Mill—$2^{3}/_{8}$" to $5^{1}/_{2}$"

NATION-WIDE ENGINEERING AND CONSTRUCTION SERVICES TO THE STEEL INDUSTRY

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PATTERSON-EMERSON-COMSTOCK, INC.
3247 GRAND AVENUE
OAKLAND, CALIFORNIA

PATTERSON-EMERSON-COMSTOCK OF INDIANA, INC.
6911 WEST CHICAGO AVENUE
GARY, INDIANA

PATTERSON-EMERSON-COMSTOCK OF ALABAMA, INC.
3808 FIFTH AVENUE NORTH
BIRMINGHAM 12, ALABAMA

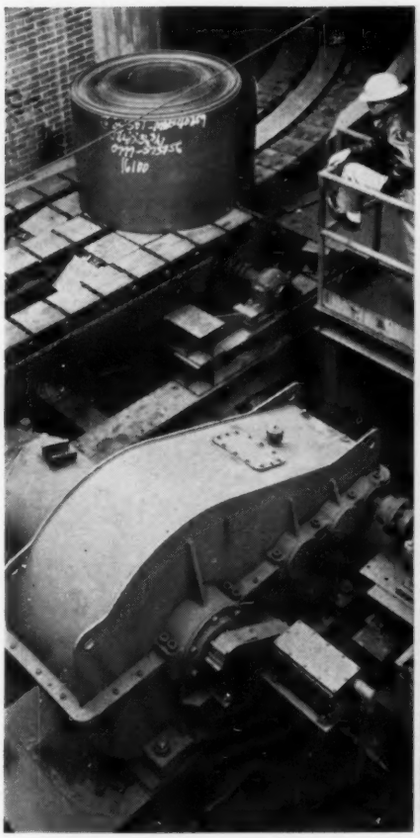
LINK-BELT conveyor system provides smooth, nonstop handling from new hot strip mill to banding and storage

"Expressway"

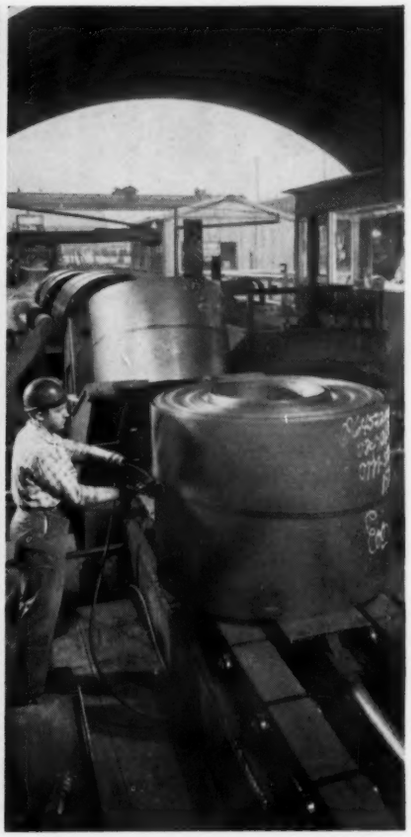
The new 44-in. semi-continuous hot strip rolling mill at Jones & Laughlin's Aliquippa Works can turn out a coil every 40 seconds. And as fast as the coils are produced, a system of Link-Belt conveyors transports them to a banding and pickup station about 425 feet away. The smooth, continuous Link-Belt route assures gentle handling of the giant coils . . . minimizing telescoping and scuffing of edges.

The Link-Belt system consists of two double-strand flat-top roller chain conveyors, two triple-strand transfer conveyors, one 90-degree continuous turn conveyor, one downtilter and a V-top wide-pallet storage conveyor. An unusual feature of the system is the continuous turn conveyor—an improved method for making a 90-degree directional change in coil travel.

As at Aliquippa, Link-Belt will work with your engineers, consultants and builders of mill and processing equipment to update your handling of coils, any other form of steel, or bulk materials. For complete details, contact your nearest Link-Belt office. Ask for Book 2764. Ask, too, about our 16-mm sound-color film, HANDLING MATERIALS IN THE STEEL INDUSTRY.



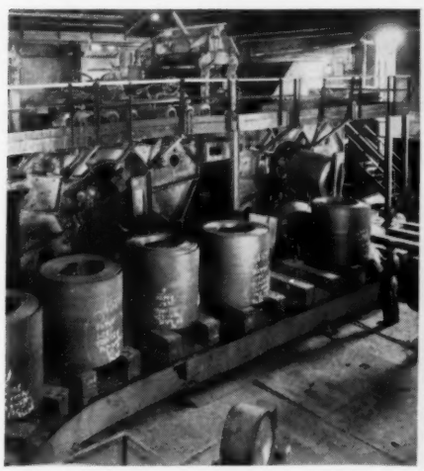
SMOOTH TURN—At this 90-degree turn in Aliquippa's Link-Belt system, a transfer conveyor moves coils onto a two-strand continuous turn conveyor. Chains of the turn conveyor have a special pin and joint design that permits bending in a horizontal as well as a vertical plane.



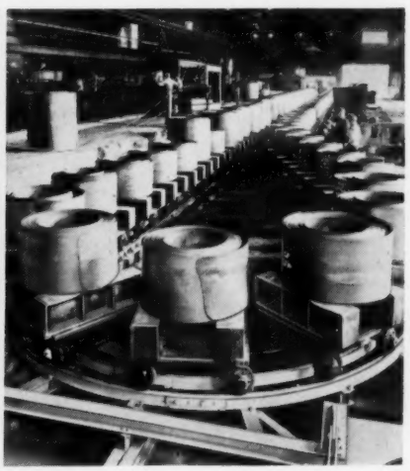
END OF THE LINE—Upon arriving at banding station, coils are lifted from conveyor by hydraulic dolly and operator applies band. Coils are then positioned on downtilter which places them on V-top wide-pallet storage conveyor. Lift pads on downtilter avoid scuffing of coil edges.

for hot coils at Aliquippa

ALSO . . . COILS AT J & L PITTSBURGH AND CLEVELAND WORKS RIDE LINK-BELT CONVEYOR SYSTEMS



CLEVELAND—Link-Belt car-type conveyor at Cleveland Works is about 1,000 ft. long . . . carries hot coils smoothly around corners up and down inclines.



PITTSBURGH—This double-strand Link-Belt conveyor, one of two installed at Jones & Laughlin's Pittsburgh Works, easily handles coils weighing up to 60,000 lbs.

LINK-BELT

MATERIALS HANDLING, PROCESSING & POWER TRANSMISSION EQUIPMENT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There are Link-Belt Plants, Warehouses and District Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,564

200-ton Universal Type Morgan Ingot Stripper Crane; 87' 0" span—15-ton auxiliary hoist.

At J&L's Aliquippa Works...

MORGAN CRANES SHARE IN VITAL PRODUCTION

15-ton Morgan Soaking Pit Crane; 68' 0" span —25-ton auxiliary hoist.

Here, as well as at other Jones & Laughlin mills, Morgan cranes have long been employed on vital production operations. The stripper crane shown was installed several years ago; the soaking pit crane is a more recent addition.

Repeat orders for heavy duty Morgan cranes and mill machinery are evidence of Morgan Engineering Company's awareness of the exacting needs of metal producers. That's why Morgan equipment shows low operating and maintenance costs, plus maximum efficiency.

When planning mill expansions or modernization, get in touch with Morgan Engineering.

THE MORGAN ENGINEERING CO. *Alliance, Ohio*

E.O.C.I. MEMBER

Overhead electric traveling cranes, gantry cranes, open hearth special cranes, blooming mills, structural mills, shears, saws, auxiliary equipment and welded fabrications.

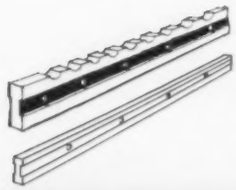
JONES & LAUGHLIN TALKED TO TREADWELL...

. . . about cinder cars for the newly expanded J & L Aliquippa Works. Needed: Cinder cars permitting the operator to dump in both directions by means of simple controls. The TREADWELL solution: "two-way dump" cars operated by moving a single valve handle towards the direction in which the pot is to be dumped. TREADWELL has supplied a total of forty six 340-cubic-foot-capacity, single pot, air dump cinder cars to the Aliquippa Works since 1928, in addition to fourteen mixer-type hot metal cars of 194 net ton capacity. Like other longtime TREADWELL customers, J & L has found that "talking to TREADWELL" results in imaginative engineering and dependable quality. For sound planning, TALK TO TREADWELL — soon.

M. H. TREADWELL COMPANY, INC.
140 CEDAR ST. NEW YORK 6, N. Y. ☎ WOrth 4-3344
SALES OFFICES:
1015 Farmers Bank Building, Pittsburgh 22, Pa.
208 South La Salle Street, Chicago 4, Illinois
SALES REPRESENTATIVES:
Shook & Fletcher Supply Company
1814 First Avenue North, Birmingham, Alabama
R. A. Ashby, 7 Live Oak Way, Kentfield, Calif.

TREADWELL
CINDER CARS

TR 42 ENGINEERING AND DESIGN SERVICES: Cost Studies—Preliminary Engineering—Complete Engineering and Design for New Plants or Expansions.



Hot shearing with Heppenstall's Rotary Curved Crop Knives. Heppenstall knives are made from a wide variety of electric steel grades to assure maximum service at various shearing speeds.

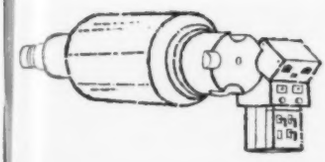
HEPPENSTALL

cuts it

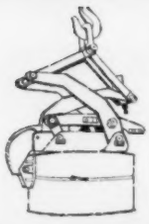
rolls it

handles it

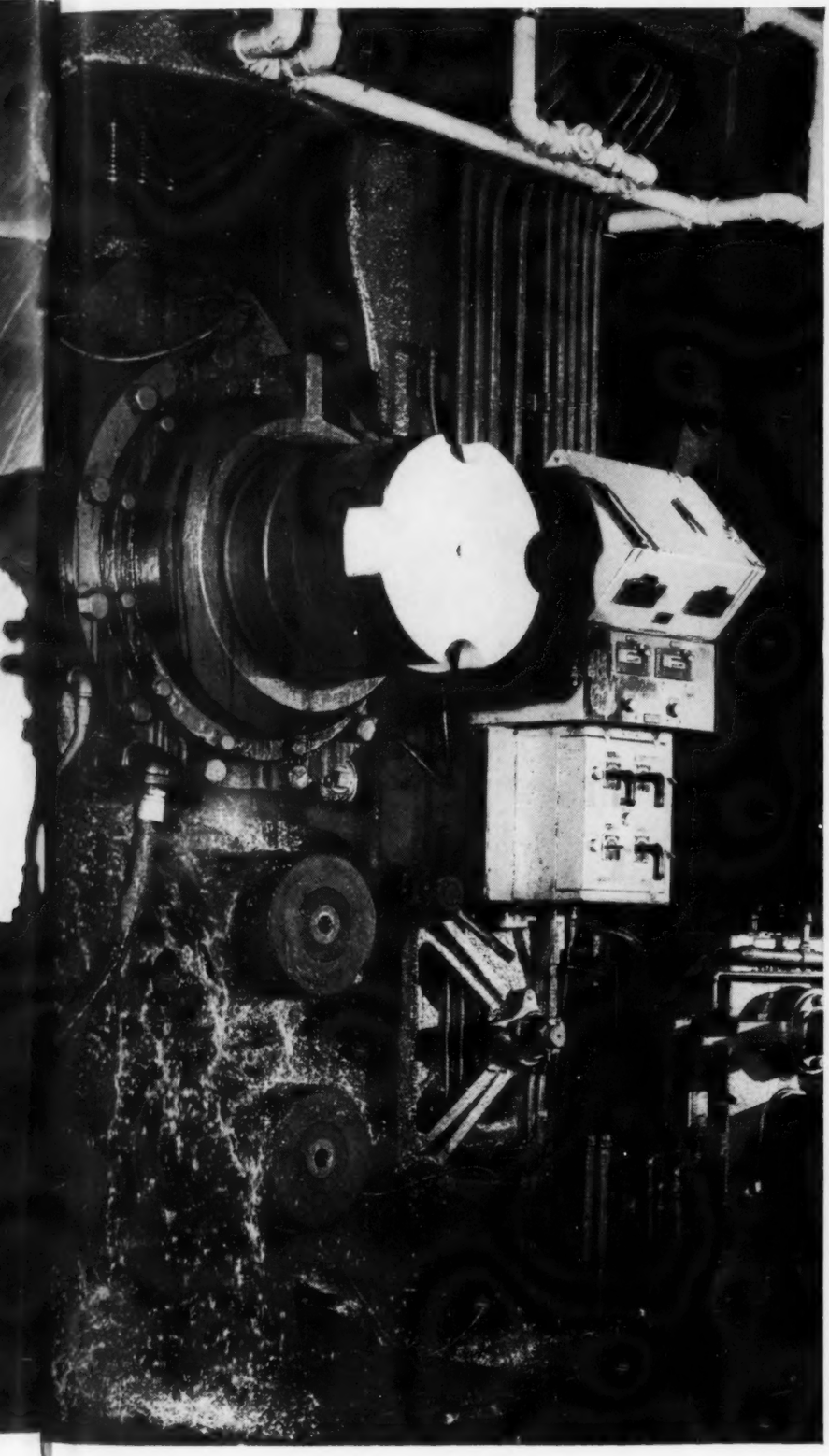
at J&L Aliquippa...



Midvale-Heppenstall rolls in six stands of hot strip mill. Heppenstall and Midvale-Heppenstall rolls and sleeves are made from highest quality alloy steel, thoroughly worked under modern hydraulic presses to obtain maximum density and grain refinement.



20,000 lb. capacity Heppenstall Coil Tongs load it for delivery. "If it hangs from a crane, Heppenstall can handle it." Stock tongs are ready for immediate delivery; custom designs are made for special requirements.



HEPPENSTALL COMPANY PITTSBURGH 1, PENNSYLVANIA
Plants: Pittsburgh and New Brighton, Pa. • Bridgeport, Conn.

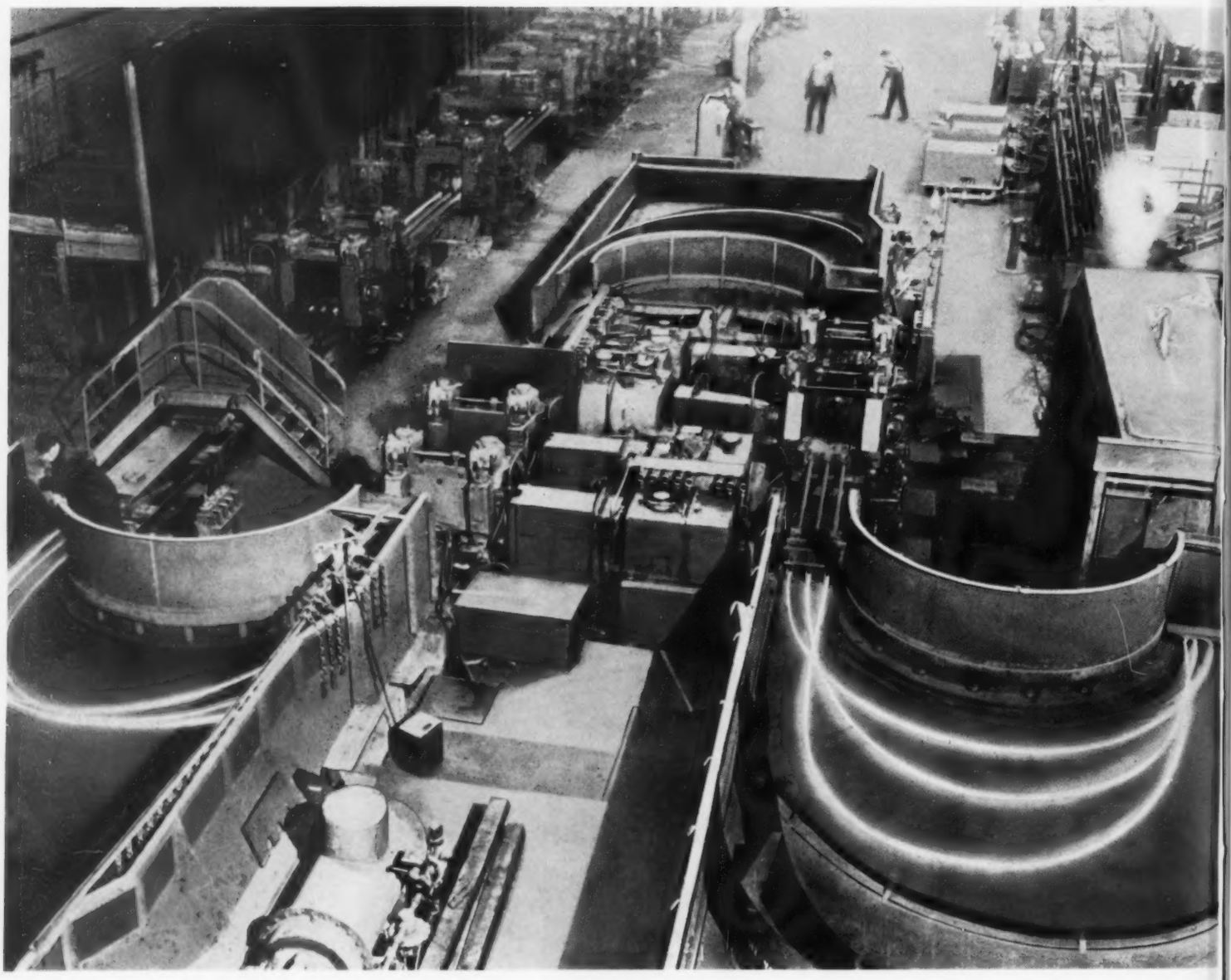
MIDVALE-HEPPENSTALL COMPANY NICETOWN, PHILADELPHIA 40, PA.

Die Blocks • Forgings • Back-Up Roll Sleeves Rings • Industrial Knives • Materials Handling Equipment • Pressure Vessels • Hardened and Ground Steel Rolls • Vacuum and Consumable Electrode Melted Steels 9253

UNITED®

RENDLEMAN ROD MILL

attains highest rate for



Rod zips through this United Rendleman mill with fewer roll changes; at lower maintenance cost. Less billet conditioning necessary. J&L Aliquippa Plant.

Designed and Built by

UNITED

ENGINEERING AND FOUNDRY COMPANY

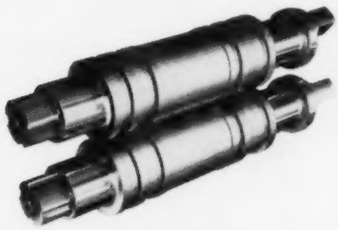
PITTSBURGH, PENNSYLVANIA

OTHER UNITED PRODUCTS

ROLLING MILLS

Blooming • Slabbing • Plate • Universal 2, 3, 4 High • 4 High Hot Strip • Continuous Billet and Bar • Rail and Structural • Merchant Bar and Rod • Continuous Rod • Sheet • Skelp • 2 and 4 High Cold Strip • Tin • Uni-Temper.

In all types: Single Stand, One Way or Reversing, Tandem, Continuous, etc. for Carbon Steel, Alloy Steels, Copper, Brass, Aluminum, Magnesium, Titanium and other Nonferrous Metals.



ROLLS

United Special Grain and Chill • United Regular Chill • United Nickel Chill • United Moly Chill • United Special Process • Chill Type • Grain Type • Chill Grain • UX Chill and Grain • United MX • United "T.G." • United Rail Finishing • United Special Grade Alloy Steel • United Carbon Steel • United Adamite • United "D.U." • United Van X • United Back-Up (B.K., Super X, Apex) • United Floor Plate.

AUXILIARY EQUIPMENT

Ingot Cars • Manipulators • Edgers • Mill Tables • Transfers • Hot Beds • Structural Straighteners • Bloom Shears • Vertical Shears • Hot and Cold Saws • Rod Reels • Hot Strip Reels • Flying Shears • Shearing Lines • Flying Strip Sample Punches • Billet Bundle Busters • Slitting and Trimming Lines • Steam Hydraulic Forging Presses • Electro-Hydraulic Forging Presses, Piercing Presses • Hydraulic Presses • Universal Couplings • Plate and Squaring Shears • Precision Levellers • Cone Type Uncoilers • Coil Boxes • Upcoilers and Downcoilers (Strip) • Cold Strip Reels • Cone Worm Drives • Gear Reduction Units • Generated Gears and Pinions • Cast Tooth Steel Mill Pinions • Processing Scale Breakers • Continuous Strip Picklers • Semi-Continuous Strip Picklers • Continuous Annealing Lines • Electrolytic Strip Cleaning Lines • Electrolytic Strip Tinning and Coating Lines • United Mill Lubricating Systems • Material Handling Equipment • Portable Crop Shears • Lever Shears • Roll Lathes and Rollafeeds • Pressuremeters • Heavy Weldments • Annealing Boxes • Iron and Steel Castings.

UNITED
ENGINEERING AND FOUNDRY COMPANY
PITTSBURGH, PENNSYLVANIA

JL-59

Even the most modern steel mills require the BEST IN LIGHTING

Seeing conditions are excellent in Jones & Laughlin's hot strip rolling mill, which represents an investment of $36 million. In the left background is shown the reversing rougher, operated by programmed, digital automatic control. The operator need only push a single button to initiate the complete rolling sequence.

J&L STEEL

Jones & Laughlin Steel Corporation's 44-inch hot strip rolling mill at Aliquippa shows how modern steel operations and good lighting go hand-in-hand.

The 975-foot building, that houses both the automatic roughing units and finishing stands, in one continuous sequence, must have the very best lighting available. J & L knows that when adjustments or repairs to equipment are necessary, there's no time to waste. Skilled attendants must have good, uniform light if they are to do their job quickly and efficiently. There's a tremendous investment in a plant such as this. It just isn't good business to keep it idle a second longer than necessary.

To supply the necessary light, two rows of 1,000-watt, color improved, mercury lamps, mounted 50 feet above the floor, are used. This assures efficient distribution of light, to make seeing easy throughout the plant.

Duquesne Light's specialists can help you have the very best lighting to suit your requirements, whether in a plant, office, or wherever seeing is important. Our consulting service is available at your request. There's never a charge—no obligation.

DUQUESNE LIGHT COMPANY
INDUSTRIAL DEPARTMENT
435 SIXTH AVENUE • PITTSBURGH 19, PA. • GRant 1-4300, Line 6630

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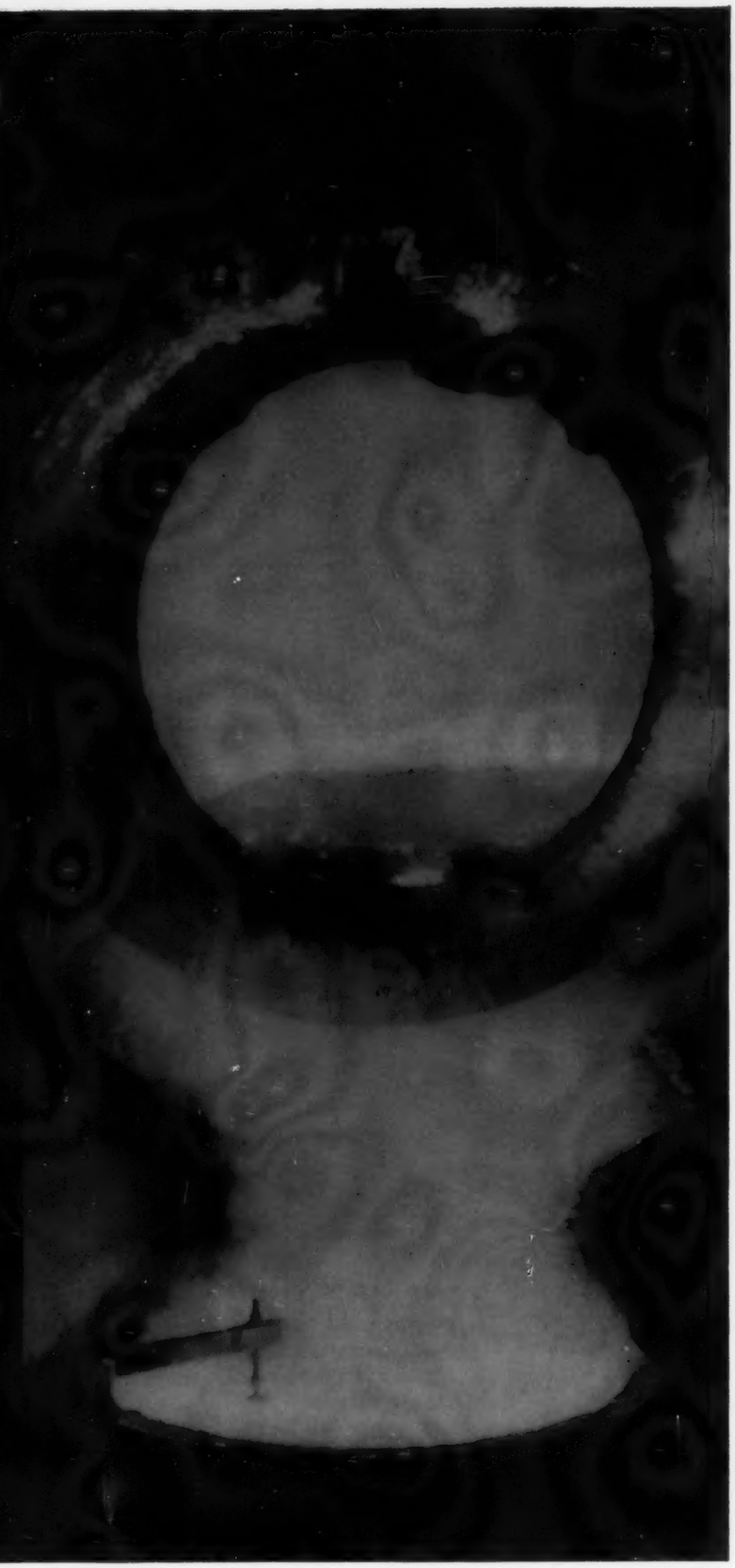

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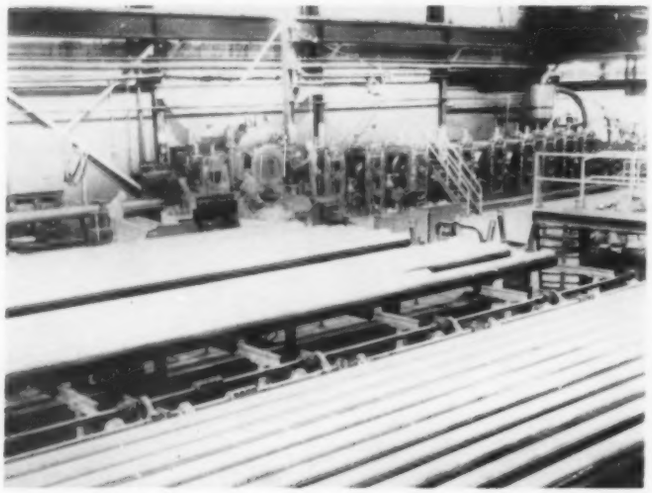

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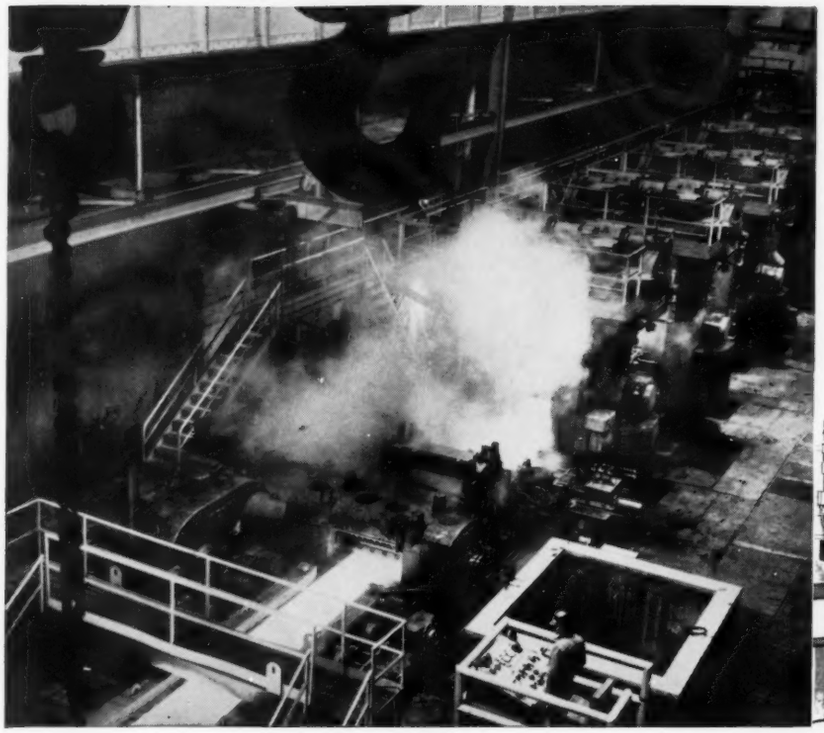

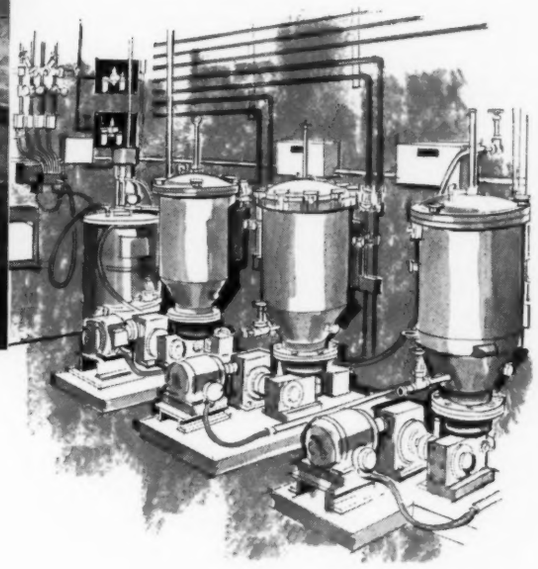

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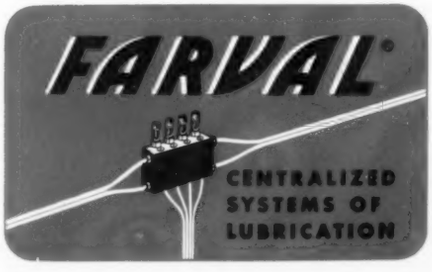

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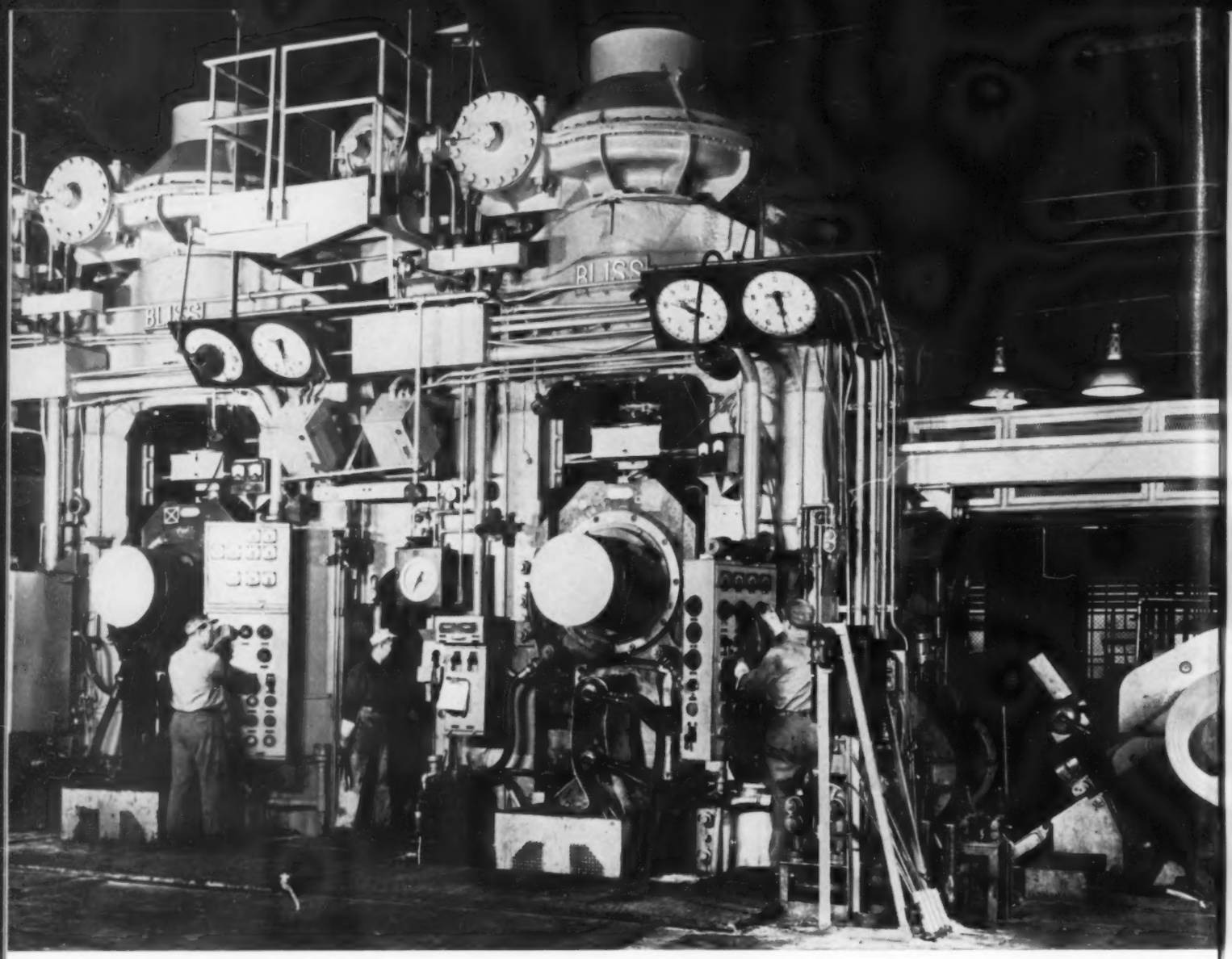

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Analysis of Operational Factors Derived from Hot Strip Mill Tests

by JOHN S. RIDE,
Metallurgist,
Development and Special Duties Div.,
Metallurgical Dept.,
The Steel Co. of Canada, Ltd.,
Hamilton, Ontario, Canada

SINCE the introduction to the steel industry of rolling as a means of breaking down and forming semi-finished and finished products, much work has been carried out to determine formulae which satisfactorily represent the relationships existing during rolling. The majority of the work has been done using experimental single stand mills operating under closely controlled conditions, but the resulting equations do not appear to be capable of representing accurately the situations existing in a multistand continuous mill in actual practice.

For the past six years The Steel Company of Canada, Ltd., has been undertaking an extensive investigation of the operation of its hot strip mill in an attempt to improve its productivity. In May, 1959, Syracuse University Research Institute, under contract to the Joint Roll Research Committee of the Association of Iron and Steel Engineers and the Roll Manufacturer's Institute, carried out a comprehensive test program on the 56-in. hot strip mill at Hamilton Works. In conjunction with this program, The Steel Company of Canada, Ltd., collected additional data to supplement and confirm previous studies made on this mill.

The 56-in. hot strip mill at Hamilton Works of The Steel Company of Canada consists of a 4-high, 110-in. reversing rougher powered by a 6000-hp drive motor feeding steel to a six stand 4-high, 56-in. continuous finishing train. Stands 1 to 5 of the finishing train are each driven by a 3500-hp motor, with a 3000-hp drive motor on stand 6. A 600-volt common d-c bus fed from four 3500-kw generators in parallel powers the six drive motors.

The 56-in. hot strip mill was instrumented in standard fashion, but, as the Syracuse University Research Institute program required the monitoring of a far greater number of parameters, a considerable expansion of the instrumentation was carried out. The work involved in this increased instrumentation is described by N. S. Wells, in paper "Instrumentation for Hot Strip Mill Test Program," in this issue, pages 90–95.

With the greater capacity for data collection now available, the scope of previous investigations could be broadened. Such studies as the measurement of the actual drafts taken on each stand, the magnitude and direction of slip occurring in each individual stand and the derivation of equations relating rolling loads to the more common parameters could now be made. From data collected on over 4000 coils, the following investigations have been carried out:

1. The accurate measurement of interstand strip speeds, and hence the actual drafts taken in each stand.

2. The derivation of an equation relating roll separating force to several rolling parameters for the entire finishing train.

3. The calculation of the magnitude of forward slip occurring in each stand between the work rolls and the strip.

4. The possibility of the existence of slip between mating work and back-up rolls.

5. The derivation of nomograms relating initial slab dimensions to rolling time on the reversing rougher, entry temperature to the continuous finishing train and head and tail end finishing temperatures after the continuous finishing train.

The investigations into the possibility of slip between mating work and back-up rolls and the magnitude of forward slip between the work rolls and the strip are of interest from the theoretical viewpoint, although both may have an effect on the amount of wear occurring on the work and back-up rolls. The other investigations are of considerable importance from operational and productivity points of view.

MEASUREMENT OF INTERSTAND SPEEDS AND DRAFTS

In most fundamental equations relating rolling parameters to roll separating force, specific roll pressure or torque, the amount of reduction appears either in the form of per cent reduction in thickness or draft. Under controlled conditions and using a single stand mill, as most investigators have done, the determination of either per cent reduction or draft is extremely simple. However, when one is faced with this problem on a multi-stand mill, what was previously extremely simple becomes comparatively difficult. It is not, of course, possible to stop the mill with steel in all stands and then hand gage the strip, while the provision of some type of interstand thickness measuring device is impractical, both from an operational and an economic viewpoint, and the use of the calculated work roll speeds provides, at the best, a very poor approximation due to the existence of forward slip. Thus it became necessary to develop a method of determining the actual drafts taken on each stand which would not interfere with the normal operation of the mill.

For the measurement of roll separating force for the Syracuse University Research Institute program, bolted type strain gage units had been fitted to each stand on the outside of the exit drive side housing. A detailed description of the mounting and calibration techniques for these units is given by N. S. Wells [1]*. This test equipment had been designed to permit the measurement of interstand speeds by paralleling the signals from each strain gage and displaying them on a single channel recording oscilloscope. To provide a measure of the exit speed of the strip from No. 6 stand, a hot metal detector was located at a known distance from the center line of No. 6 stand and its signal exhibited on the same oscilloscope. The thickness of the head end of the bar was measured prior to entering No. 1 stand and the thickness of the tail end of the coil measured in the coiler pit to provide the data necessary for the calculation of the actual drafts.

Unfortunately, this relatively simple method suffered from several shortcomings which necessitated some elaboration of the system. The use of an existing limit switch between the crop shear and the scale-breaker at a known distance from the center-line of No. 1 stand which operates the mill sprays allowed an accurate measurement to be made of the entry velocity of both the head and tail of the strip into No. 1 stand. A second hot metal detector was placed between the original one and No. 6 stand to provide a closer check

* Numbers in parentheses refer to Bibliography at end of paper.

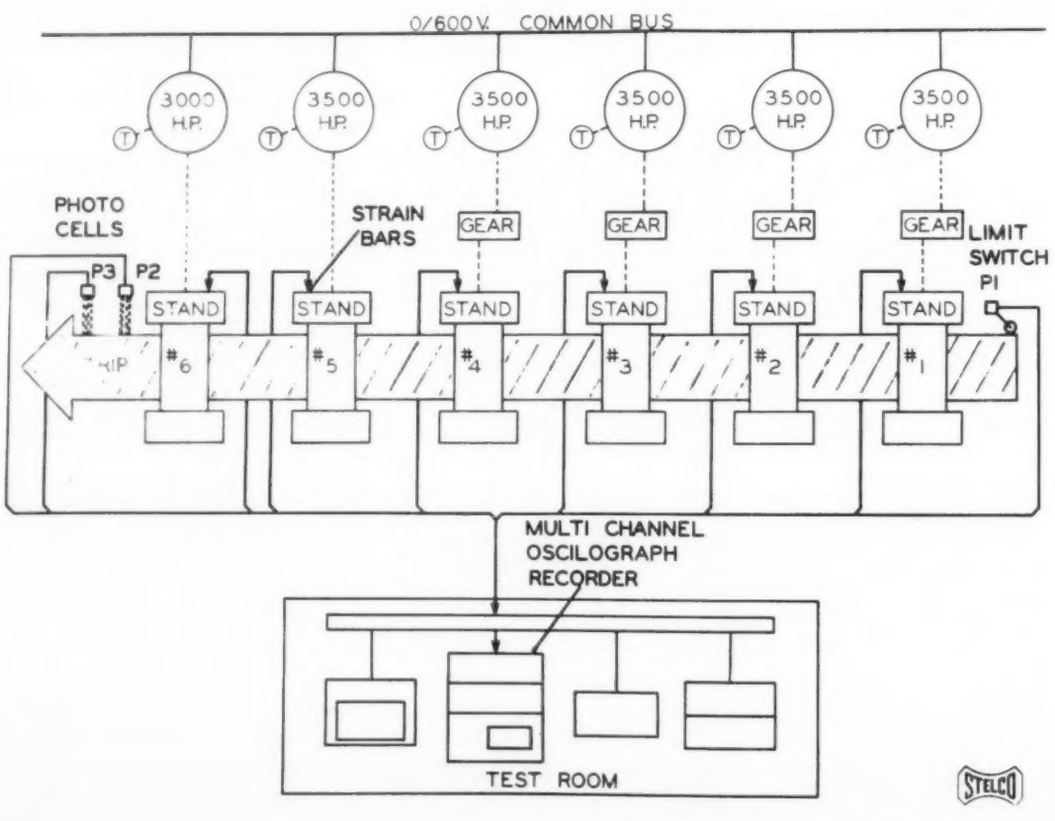


Figure 1 — This mill arrangement and instrumentation was used for measurement of interstand speeds.

on the exit speeds from No. 6 stand. A schematic representation of the final instrumentation is shown in Figure 1. P_1 is the limit switch located 18 ft before No. 1 stand, P_2 is the first hot metal detector situated 25 ft after No. 6 stand and P_3 is the second hot metal detector 46 ft from the center-line of No. 6 stand. The distance between work roll centers on all stands is 18 ft. The signals from the bolted type strain gage units are fed into a terminating and balancing box, collected in parallel and exhibited on one channel of a four-channel recording oscilloscope as a cumulative cascade. The signals from P_1, P_2 and P_3 are exhibited on the other three channels. The 60-cycle timing wave exhibited in one margin was used to provide an accurate base for time measurements. A nonscalar diagram of a typical sequence on the recording oscilloscope is shown in Figure 2. To enable the highest order of accuracy to be attained, the recording of the strain gage and detector signals was made using the highest possible chart speeds, allowing a scale accuracy of five milliseconds. Again, the thickness of the strip was measured before No. 1 stand and in the coiler pit, using hand micrometers.

As the distances between the various sensing elements of the system are known, as well as the incoming head end thickness and the outgoing tail end thickness, and interstand times for the head and tail of the coil, it then becomes possible to calculate interstand speeds and interstand thicknesses. It was decided to use, where possible, the measurements for the tail of the coil to minimize the effects on speed of the droop of the motors and the drop in generator volts induced by the impact load caused by the entry of the head end of the coil into each stand. This, it was felt, would tend to more closely represent steady state conditions in the mill and give more precise measurements of the speeds, thicknesses and drafts. The speeds for the distances $6 - P_2$, $6 - P_3$ and $P_2 - P_3$ were calculated and it was found that they differed by no more than ± 1 per cent with the speed $6 - P_3$ being approximately the arithmetic mean. For this reason, it was decided to use the speed calculated over the distance $6 - P_3$ as the exit speed of the strip from the mill. Table I shows the computed entry and exit interstand speeds for 6 representative coils of various gages. Table II shows the interstand thicknesses and drafts calculated using the exit interstand speeds. It should be noticed that the computed tail thickness agrees very closely with the measured value in all these cases. A relatively close agreement is maintained throughout the entire sample, the average deviation of the calculated tail thickness from the measured thickness being -0.004 in., for a sample of over 400 coils. Thus it is apparent that the computed drafts for each stand are very close to those actually being taken.

It is of interest to compare the drafts as computed above with those that would be computed by an operator in actual mill operation. It is the practice at The Steel Company of Canada to first determine a thickness constant by multiplying the ordered gage by the speed of No. 6 stand as calculated from the roll rpm indicator and the new roll diameter. To obtain the outgoing thickness off any stand, this thickness constant is then divided by the speed of that stand. This method of calculation has been applied to the six representative coils used in Tables I and II. Table III shows actual roll speeds for these coils and the interstand thicknesses as the roller would compute them. Table IV compares

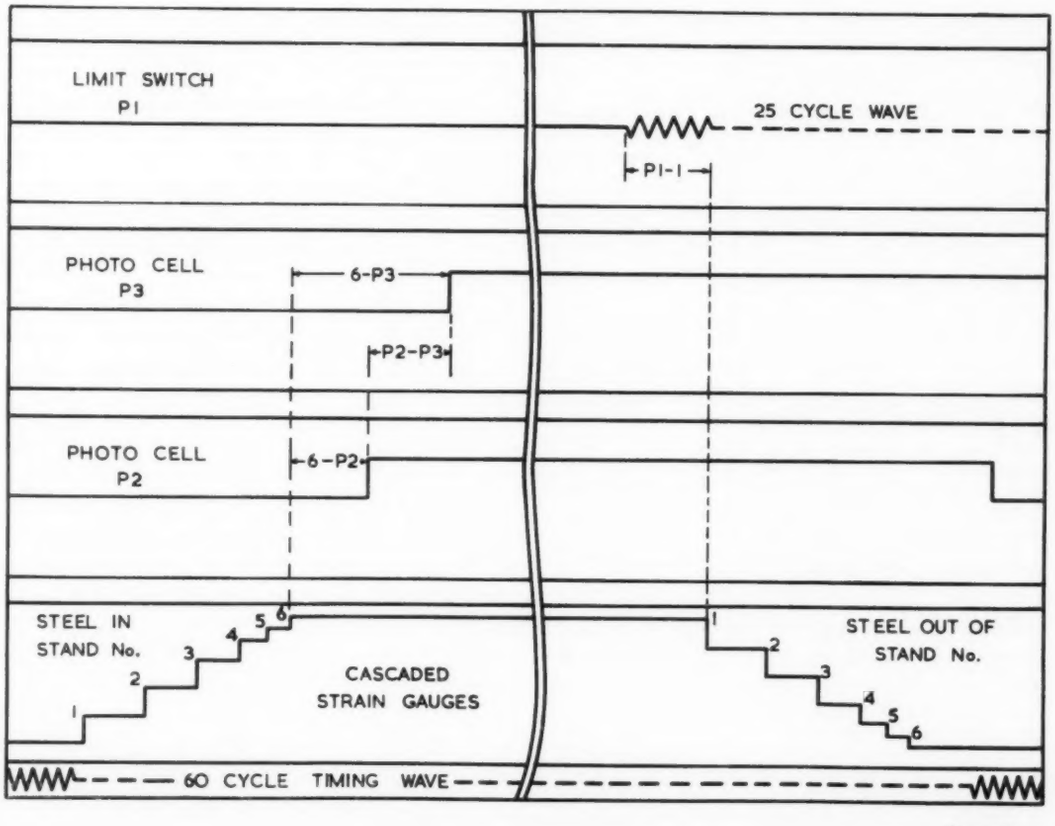


Figure 2 — Non-scalar diagram of recording oscilloscope chart for measurement of interstand speeds.

TABLE I

Coil no.	Slab size, in.	Ordered gage	Entry interstand speed, fpm						Exit interstand speed, fpm						
			1–2	2–3	3–4	4–5	5–6	6–P_3	P_1–1	1–2	2–3	3–4	4–5	5–6	6–P_3
673-1-31	5 × 41	0.128	373.57	572.94	800.59	1014.08	1228.67	1385.54	251.28	396.04	588.24	832.05	1069.31	1291.87	1456.76
830-1-31	4¾ × 37½	0.110	353.63	576.92	804.17	1036.47	1239.95	1376.56	202.02	372.03	585.05	836.56	1082.16	1296.52	1439.33
881-1-31	5¼ × 36½	0.104	348.27	598.01	842.43	1094.22	1361.92	1567.29	210.28	374.22	622.12	861.24	1144.07	1453.57	1672.61
910-1-31	5½ × 35	0.080	308.57	556.13	857.14	1141.65	1422.92	1612.15	168.22	327.37	578.78	906.80	1210.76	1545.06	1750.47
940-1-31	5¼ × 36	0.070	334.99	604.36	906.04	1220.34	1516.85	1752.38	168.86	351.56	639.43	945.71	1288.78	1646.34	1901.98
187-2-1	5 × 28½	0.059	301.00	531.23	790.05	1111.11	1471.39	1733.67	151.01	312.50	546.28	812.03	1146.50	1553.96	1830.95

TABLE II

Coil no.	Entry thickness, in.	Calculated interstand thickness, in.						Measured tail thickness, in.	Draft, in.					
		1–2	2–3	3–4	4–5	5–6	Tail		1	2	3	4	5	6
673-1-31	0.785	0.498	0.335	0.237	0.184	0.153	0.135	0.134	0.287	0.163	0.098	0.053	0.031	0.018
830-1-31	0.830	0.451	0.287	0.200	0.155	0.129	0.116	0.119	0.379	0.164	0.087	0.045	0.026	0.013
881-1-31	0.830	0.466	0.281	0.203	0.153	0.120	0.104	0.107	0.364	0.185	0.078	0.050	0.033	0.016
910-1-31	0.840	0.432	0.244	0.156	0.117	0.091	0.081	0.083	0.408	0.188	0.088	0.049	0.026	0.010
940-1-31	0.835	0.401	0.221	0.149	0.109	0.086	0.074	0.076	0.434	0.180	0.072	0.040	0.023	0.012
187-2-1	0.760	0.367	0.210	0.141	0.100	0.074	0.063	0.064	0.393	0.157	0.069	0.041	0.026	0.011

TABLE III

Coil no.	Roll surface speed, fpm						Ordered gage, in.	Calculated interstand thickness, in.					Measured entry thickness, in.
	1	2	3	4	5	6		5–6	4–5	3–4	2–3	1–2	
673-1-31	371.03	540.38	794.83	1015.81	1224.25	1379.61	0.128	0.144	0.174	0.222	0.332	0.476	0.785
830-1-31	350.21	538.10	791.60	1023.81	1224.25	1367.96	0.110	0.123	0.147	0.190	0.280	0.430	0.830
881-1-31	347.76	558.62	830.37	1079.80	1351.30	1530.96	0.104	0.118	0.147	0.192	0.285	0.458	0.830
910-1-31	305.76	515.40	837.85	1135.79	1432.15	1606.63	0.080	0.090	0.113	0.153	0.249	0.420	0.840
940-1-31	333.99	558.17	889.02	1207.78	1530.32	1775.44	0.070	0.081	0.103	0.140	0.223	0.372	0.835
187-2-1	288.15	496.92	766.40	1075.80	1426.37	1676.48	0.059	0.069	0.092	0.129	0.199	0.343	0.760

TABLE IV

Coil no.	Per cent reduction											
	Using exit interstand speeds						Using roll surface speeds					
	1	2	3	4	5	6	1	2	3	4	5	6
673-1-31	36.6	32.7	29.3	22.4	16.8	11.8	39.4	30.3	33.1	21.6	17.2	11.1
830-1-31	45.7	36.4	30.3	22.5	16.8	10.1	48.2	34.9	32.1	22.6	16.3	10.6
881-1-31	43.9	39.7	27.8	24.6	21.6	13.3	44.8	37.8	32.6	23.4	19.7	11.9
910-1-31	48.6	43.5	36.1	25.0	22.2	11.0	50.0	40.7	38.6	26.1	20.4	11.1
940-1-31	52.0	44.9	32.6	26.9	21.0	14.0	55.4	40.1	37.2	26.4	21.4	13.6
187-2-1	51.7	42.8	32.9	29.1	26.0	14.9	54.9	42.0	35.2	28.7	25.0	14.5

the per cent reduction as calculated by the two methods. It can be seen that the figures agree within approximately one per cent for stands No. 4, 5 and 6, but that as the strip thickness increases, i.e., in the earlier stands, the discrepancy increases to about three per cent. It is quite possible that such a discrepancy could have a considerable effect if the per cent reductions as computed by the operator's method were used in the calculation of roll separating force. However, it must be stated in all fairness that this method is perfectly acceptable for day-to-day operation of a mill, and the more elaborate method is only required for an investigation of rolling theory or for the development of automatic control systems.

RELATIONSHIP OF ROLLING PARAMETERS TO ROLL SEPARATING FORCE

Previous investigations into the relationship between rolling parameters and roll separating force, specific roll pressure or torque in hot rolling have produced formulae that are excellent from the theoretical standpoint, but which, when applied to a continuous mill in actual practice, leave much to be desired. Many authors have noted the failure of the "classic" formulae to produce results comparable to measured values, but little headway has been made in correcting this situation. Possibly the main fault lies in the fact that the "classic" formulae have been derived using single stand mills under closely controlled conditions, while in multi-stand mills the effects of the various parameters become more complicated.

An attempt has been made to derive a preliminary relationship between roll separating force and various rolling parameters for the 56-in. hot strip mill of The Steel Company of Canada, Ltd. The Syracuse University Research Institute investigation required the collection of data on roll separating force and roll fpm for No. 2 and No. 5 stands, together with certain temperature data and approximate figures for per cent reduction on these stands. It was decided to equip all stands with strain measuring devices to determine the actual forces occurring under normal operating conditions. A considerable volume of data was amassed for all stands except No. 3. Unfortunately, during the test period, the strain wafer fractured and a replacement could not be obtained and calibrated in time to allow data to be collected.

The four main parameters which appear to have the greatest effect on the magnitude of the roll separating force are draft, speed, temperature and the thickness of the strip entering the stand. It was therefore decided to attempt to relate these variables to the roll separating forces as measured by the strain gages, using statistical methods. At the moment it is not possible to simultaneously measure roll separating force and actual drafts, thus introducing a source of inaccuracy into the relationship by the necessity of either using the operator's method for the computation of per cent reduction or of using actual per cent reductions calculated for coils of similar gage from slabs of the same size but rolled approximately nine months after those on which the roll force measurements were taken. In the latter case the assumption that conditions have not changed to a marked degree must be made. This premise has been accepted, it being supported by the fact that our product distribution is similar to that of a year ago and that our production rate has remained relatively constant over the period in question. Furthermore, since the instrumentation at present on the mill does not allow for the simultaneous measurement of roll separating force and draft, and since, until this is possible any relationships derived must be regarded as purely exploratory, the above assumption can be regarded as valid.

Thus, for the purposes of this investigation, average values for draft or per cent reduction and for entry thickness were determined for combinations of ordered gage and original slab size. These average values were then applied to coils of similar gage originating from similar slabs on which roll separating force data had previously been collected.

The introduction of temperature into the relationship also posed a problem as sufficient equipment was not available to measure the strip temperature prior to each stand. However, as the temperatures prior to No. 1 stand and after No. 6 stand were recorded, it was decided that, for this exploratory investigation, a simple interpolation between the head and entry temperature and the head end finishing temperature should be made. This again introduces a source of error into the relationship but it is felt that the interpolated values would be a satisfactory approximation for the purposes of this investigation.

A total sample of 975 coils was collected and, prior to statistical analysis, each parameter was plotted against roll separating force for the mill as a whole, the roll separating force increasing with increasing per cent reduction, increasing entry thickness, increasing temperature and decreasing speed. These relationships do not necessarily hold for the data for each individual stand, however, as here the roll separating force tends to increase with increasing per cent reduction, decreasing entry thickness, decreasing temperature and increasing speed as would be expected from theoretical considerations. This apparent discrepancy in the effect

of the parameters upon roll separating force is caused by the interdependence existing between them.

The plots showed a definite tendency toward a curvilinear relationship and so, in the correlation, each of the parameters was included as a parabolic function. The equation resulting from a correlation by the method of least squares, using an IBM 650 computer and library programs, is given below:

$$x_0 = 102.278 - 0.0012\,x_1 - 0.000013\,x_1^2 + 1.494\,x_2 - 0.014\,x_2^2 - 106.363\,x_3 + 71.888\,x_3^2 - 0.070\,x_4 + 0.000018\,x_4^2 \quad \ldots\ldots (1)$$

where

x_0 = roll separating force, tons per in. of strip width
x_1 = stand roll speed, fpm
x_2 = per cent reduction
x_3 = entry thickness, in.
x_4 = strip temperature, F

This equation explained 89.2 per cent of the variance in roll separating force, and indicates the validity of the choice of independent variables.

If the second derivatives are taken of the pair of terms for each variable in equation 1 it will be seen that the speed and per cent reduction reach maximum values while minimum values are obtained for entry thickness and strip temperature. This is contrary to expectations, but can be explained by the extreme amount of interdependence existing between the selected parameters. While looking at the mill as a whole, as in equation 1, it must be remembered that, in each stand, the values of the parameters are relatively constant and seldom overlap those of the neighboring stands. The inherent interaction of variables in each stand appears to be ignored in equation 1, but upon substitution of the appropriate values, a close agreement between measured and calculated forces is obtained. Figure 3 shows a nomogram constructed from equation 1 which could be used to estimate the roll separating force per in. of width for any combination of speed, per cent reduction, thickness and temperature.

If this method of attacking the problem of the relationship between roll separating force and rolling parameters can predict the rolling loads achieved in practice with a satisfactory degree of accuracy, it could be of great assistance.

It then becomes possible to use an off-line computer operating on an optimising program to establish maximum mill productivity in terms of mill settings using the derived and verified mill equations with the mill still being set manually. The use of an in-line computer, i.e., using a special computer and adaptive system techniques, for full mill automation may not be desirable. Costwise there is no comparison between the two approaches since existing mill accounting computers could be used for the off-line calculations.

It must again be emphasized that the results de-

Figure 3 — Nomogram derived from equation 1 relates rolling parameters to roll separating force per in. of strip width.

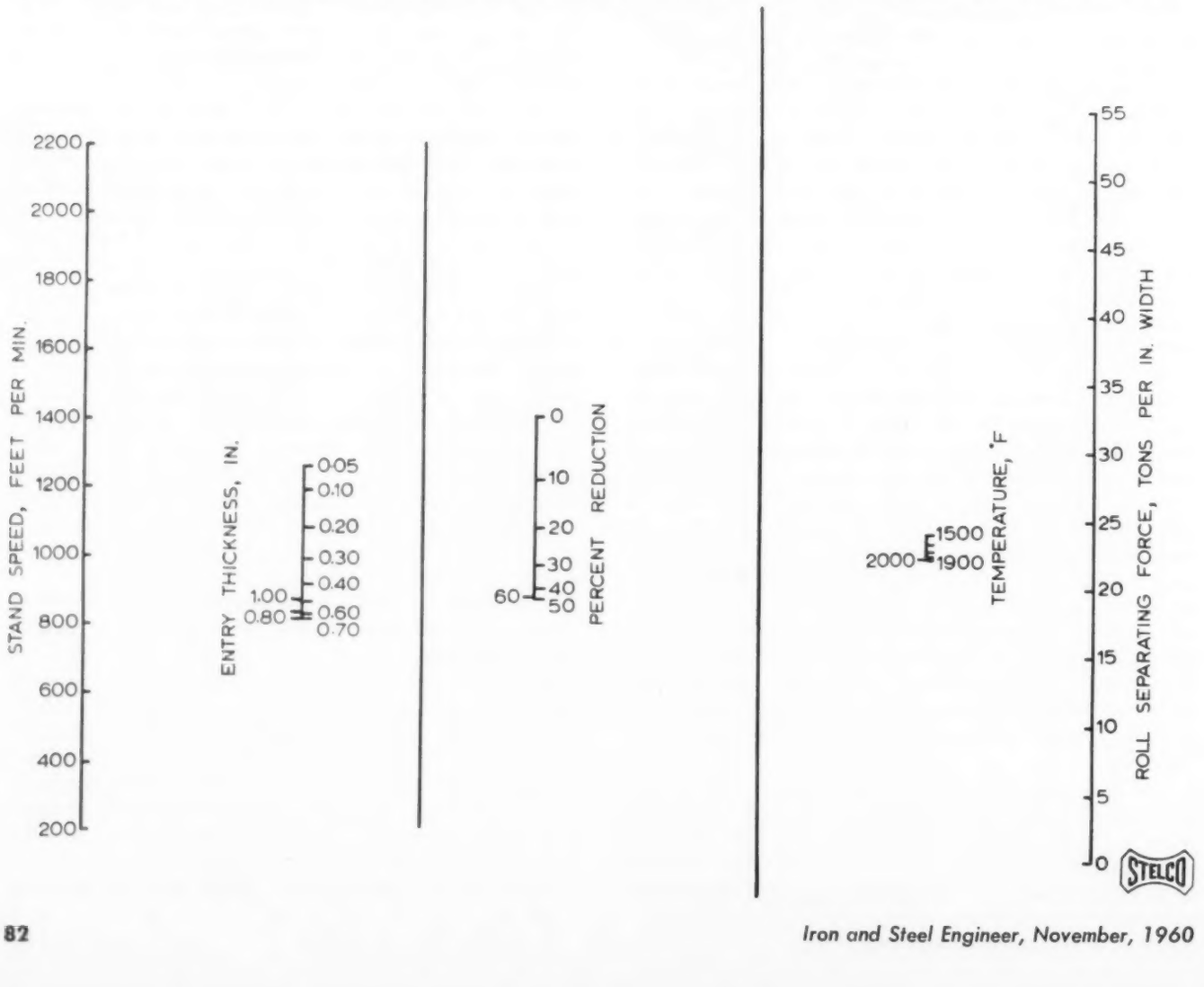


TABLE V

Coil no.	Per cent forward slip											
	Using entry interstand speeds						Using exit interstand speeds					
	1	2	3	4	5	6	1	2	3	4	5	6
673-1-31	0.68	6.03	0.72	−0.17	0.36	0.43	6.70	8.90	4.70	5.30	5.50	5.60
830-1-31	0.98	7.21	1.59	1.24	1.28	0.63	6.20	8.70	5.70	5.70	5.90	5.20
881-1-31	0.15	7.05	1.45	1.34	0.79	2.37	7.60	11.40	3.70	6.00	7.60	9.30
910-1-31	0.92	7.90	2.30	0.52	−0.64	0.34	7.10	12.30	8.20	6.60	7.90	9.00
940-1-31	0.30	8.28	1.91	1.04	−0.88	−1.30	5.30	14.60	6.40	6.70	7.60	7.10
187-2-1	4.46	6.90	3.09	3.28	3.16	3.41	8.50	9.90	6.00	6.60	8.90	9.20

scribed are only those for an exploratory investigation and are only applicable to the operations of the 56-in. hot strip mill of The Steel Company of Canada, Ltd. It is realized that, in the data used, there are some weaknesses, mainly in the parameters of per cent reduction and strip temperature. To overcome these weaknesses it will be necessary to instrument a mill with pyrometers on the entry side of each stand and to provide equipment to simultaneously measure roll separating force and accurate interstand speeds. This points to the need for considerably more data accumulating equipment on mills so that all the variables are monitored simultaneously. For this purpose analog recording systems would be too cumbersome, necessitating conversion to digital techniques. Thus, while the validity of this approach is, at the moment, uncertain, it is felt that it may provide a simplified solution for individual mills.

THE MAGNITUDE OF FORWARD SLIP BETWEEN THE WORK ROLLS AND THE STRIP

In all formulae relating rolling parameters to rolling load that have been derived, the coefficient of friction is included. As the coefficient of friction changes from point to point along the arc of contact, it necessarily follows that it has a considerable effect on the magnitude of the pressure distribution between the work rolls and the strip. It is extremely difficult to directly measure the value of the coefficient of friction and thus the measurement of slip can be of theoretical importance as a means of evaluating the magnitude and variation of the mean coefficient of external friction.

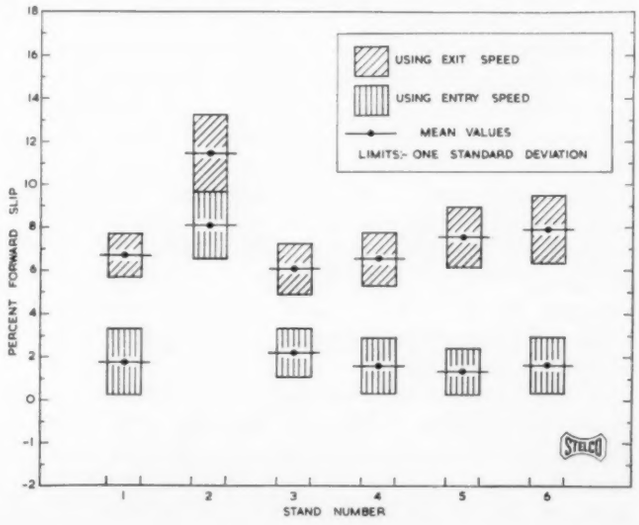
With the instrumentation available on the 56-in. hot strip mill, it was relatively easy to determine the per cent forward slip occurring in each stand. The interstand speeds of the strip are determined for the calculation of the draft being taken on each stand and the roll surface speeds could be computed with a reasonable degree of accuracy from the roll rpm and new roll diameters. The motor rpm figures as read from the meters in the speed pulpit must be corrected for meter calibration and drive gear ratio to convert them to roll rpm. It should be noted here that the resulting roll surface speeds are not exact as the changes in work roll diameter due to wear and thermal expansion are difficult to take into account. It should also be emphasized that an error in the reading of the meter in the pulpit can have a rather drastic effect on the magnitude of the per cent forward slip. An error of one division on the scale, i.e., five rpm, is equivalent to a variation of over one per cent in the value of forward slip.

As it is not yet possible to measure interstand speeds, i.e., the strip speeds, during the relatively stable conditions occurring after the head end of the coil has entered the mill and before the tail end has left the mill, it was decided to calculate the per cent forward slip for each stand using both the entry and exit interstand speeds. By so doing it may be assumed that the values so derived will be the minimum and maximum limits for each coil with the average or stable condition value lying somewhere in between. Table V shows the per cent forward slip values calculated in this fashion for the six representative coils previously listed.

Figure 4 shows the distribution of per cent forward slip from stand to stand for 16 hr rolling. The average values have been calculated using both entry and exit interstand speeds and the limits given are one standard deviation. The difference between the per cent forward slips as calculated using the entry and exit interstand speeds is probably due to the effects of the voltage regulation of the drive motors and the impact speed drop upon entry of the head end of the coil into the stand. No logical explanation can be given at this time for the high values of per cent forward slip occurring on No. 2 stand or for the much closer agreement on this stand between the values computed using the entry and exit interstand speeds.

It should be reemphasized perhaps that the values for per cent forward slip thus derived are not absolute but are subject to inaccuracies resulting from the reasons previously stated. Also, the roll speed readings were taken at a random arbitrary steady state value during the passage of a coil through the mill. To

Figure 4 — Mean per cent forward slip occurring on all stands, using both entry and exit interstand speeds.



establish the precise value of forward slip would necessitate the use of the cascaded strain gage technique plus the simultaneous accurate recording of all six stand speeds. In this way it would be possible to accurately establish the precise average speed of each mill during the transit of the head or tail of the coil to each successive stand. However, this should not detract from the fact that it is possible to measure the approximate per cent forward slip under actual operating conditions and thereby, according to some authorities, gain an insight into the variation of the coefficient of friction from stand to stand.

THE POSSIBILITY OF SLIP BETWEEN MATING WORK AND BACK-UP ROLLS

The question of the possibility of the existence of slip between mating work and back-up rolls during rolling, particularly at the moment of entry of the head end of a coil into the roll gap had been raised at meetings of the Joint Roll Research Committee. Many opinions had been expressed without a satisfactory conclusion being reached. It was decided to attempt to arrive at an answer to the question during the Syracuse University Research Institute investigation.

For this purpose the top back-up roll and the top work roll of No. 5 stand of the 56-in. hot strip mill were fitted with magnetic type pulse tachometers giving 600 counts per work roll revolution and 1000 counts per back-up revolution. These provide approximately 8 and 7 counts per peripheral inch respectively. The method of mounting the tachometers on the roll necks and the equipment and techniques used to accumulate the counts are described by N. S. Wells.[1]

Three measuring sequences were used to determine if slip occurred at any period during the rolling of a coil. These were:

1. Start count prior to entry of strip—stop count prior to exit of strip.
2. Start count after entry of strip—stop count prior to exit of strip.
3. Start count after entry of strip—stop count after exit of strip.

Using these three sequences it is possible to determine if slip occurs at entry because of the impact loading [sequence (1)], if it occurs during relatively steady state conditions [sequence (2)] or if it occurs upon release of the rolling load [sequence (3)]. Each measurement was standardized by using as a basis approximately 50 revolutions of the back-up roll, i.e., approximately 50,000 counts. The ratio of work roll counts to back-up roll counts, denoted by R, was calculated for each measurement and plotted against time. A statistical line calculated by the method of least squares was fitted to the plot. The R^2 for the sample of 282 values is 0.93, indicating that a very strong linear relationship exists between the ratio R and time. Figure 5 shows all the measured ratios plotted against time, together with the computed statistical line.

If slip between the work and back-up rolls occurred it would be logical to assume that either the ratio R would exhibit a large change with time or else the ratio R derived for one of the sequences would differ markedly from the others. As can be seen from Figure 5, there is no large change in the ratio R with time, but rather a steady increase over the test period, while there is no significant difference in the ratios for any of the sequences. From these observations it would appear reasonable to assume that no slip occurs between the mating work and back-up rolls.

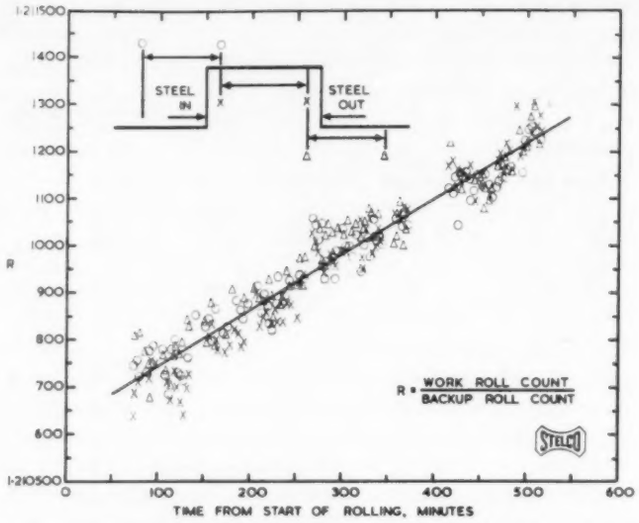


Figure 5 — Individual points and the calculated statistical line for the relationship between the ratio R and time.

This assumption can be justified mathematically. As one inch of work roll surface is equivalent to 8.7 counts and one inch of back-up roll surface is equivalent to 7.2 counts any reasonable amount of slip would change the ratio noticeably. For example:

50,000 counts on the back-up roll at a ratio of 1.211000 are equivalent to 60,550 counts on the work roll.

Now if one in. of slip occurs and the back-up roll count decreases to 49,993 counts, the ratio R changes to 1.211170, a noticeable change on the scale chosen in Figure 5.

Similarly if the work roll count increases to 60,559 for a 50,000-count on the back-up roll, again the equivalent of one in. of slip, the ratio R changes to 1.211180.

From the above two examples it is readily apparent that any small amount of slip would produce a very noticeable change in the ratio R, as the changes mentioned are equivalent to one in. in 6960 in. or 0.02 in. per back-up roll revolution. Thus the mathematical treatment completely justifies the assumption that no slip occurs between mating work and back-up rolls on our No. 5 stand. However, it should not be taken for granted that no slip occurs between the mating work and back-up rolls of all stands. It is possible that, with the heavier reductions and roll separating forces present in the earlier stands, and the resulting heavier impact loads upon entry of the strip into the mill, some slip may exist. This would have to be investigated in a similar way before any definite statements were made concerning the existence of slip in all stands.

An interesting result of this investigation is that the change in ratio R with time can probably be used as a measure of the progressive wear of the work roll, if it is assumed that no back-up roll wear occurs. At zero time on Figure 5, the ratio R of 1.210625 is equivalent

to a work roll count of 60531.25 for 50,000 counts on the back-up roll. Eight hours later, i.e., at 480 min on Figure 5, the ratio R of 1.211200 is equivalent to a work roll count of 60,560 for 50,000 counts on the back-up roll. The new work roll diameter at zero time is 21.951 in. equivalent to R = 1.210625. By simple arithmetic the ratio R = 1.211200 at 480 min after zero time is equivalent to a work roll diameter of 21.941 in. Thus an increase in the ratio R of 0.000575 is equal to a decrease in work roll diameter of 0.010 in., assuming no back-up roll wear. It should thus be feasible to assume that the gradient of the statistical line in Figure 5 is a measure of progressive work roll wear, being approximately 0.001 in. per hr. This is an accuracy of close to 1 in 22,000. It is interesting to note that after 16 hr of rolling, the cold worn diameter of this work roll was 21.926 in., giving a total wear of 0.025 in. Thus the calculated reduction in diameter of 0.010 in. after 8 hr rolling would be very close to the actual wear in that time if one takes into account the increase in diameter due to thermal expansion. The wear in the back-up roll taking place over the same period of time would be approximately 0.002 in. according to figures quoted by G. Sachs[2]. Such a quantity of wear would cause a relatively small change in the ratio R over the 8-hr period and could be safely neglected if the time increment is decreased to one hr.

NOMOGRAMS RELATING CONDITIONS ON THE 110-IN. REVERSING ROUGHER TO THOSE ON THE 56-IN. HOT STRIP MILL

Prior to 1959 considerable work had been carried out to investigate conditions existing during the rolling of a coil from a slab and to derive equations relating the various parameters. As production rates increase and as changes are made to the mill equipment, it becomes necessary to check the previously determined equations and revise them where required to meet the new conditions.

In 1955 equations had been derived to relate the following parameters:

1. Rolling time on the reversing rougher to slab thickness, width and length.
2. Head end entry temperature to rolling time and the last pass thickness off the rougher.
3. Head end finishing temperature to head end entry temperature, ordered gage and finishing speed.
4. Coil length to head end entry temperature, ordered gage, finishing speed and tail end finishing temperature.
5. Coil length to head end finishing temperature, tail end finishing temperature, ordered gage and finishing speed.

By using these equations it was possible to evaluate the performance of both the reversing rougher and the finishing train and to determine conditions for the physical and metallurgical balance of the mill as a whole.

Since 1955 production rates have increased and changes have been made in equipment and techniques, so that over this period the equations have been gradually revised. Data collected during the Syracuse University Research Institute investigation have been used to complete the revision of the equations and to produce several nomograms relating conditions throughout the mill.

On the reversing rougher, two breakdown practices are used depending on the slab dimensions, viz. three pass or five pass. For the three-pass breakdown a log-log relationship was derived as the original data plots showed a definite trend away from a linear function, while for the five-pass breakdown the use of a linear relationship was strongly supported. The derived equations are:

for three pass rolling

$$\log x_0 = -0.525 + 0.642 \log x_1 + 0.038 \log x_2 + 0.721 \log x_3 \quad (2)$$

for five pass rolling

$$x_0 = -16.447 + 10.048\, x_1 + 0.259\, x_2 + 0.079\, x_3 \quad (3)$$

where:

x_0 = rolling time, sec
x_1 = slab thickness, in.
x_2 = slab width, in.
x_3 = slab length, in.

The connecting equation linking the reversing rougher to the continuous train relates the rolling time on the rougher and the thickness of the strip leaving the rougher to the entry temperature measured at the crop shear prior to the continuous train. Equation 4 shows the relationship.

$$\log x_4 = 3.301 - 0.0142 \log x_0 + 0.0785 \log x_5 \quad (4)$$

where:

x_4 = head end entry temperature, F
x_0 = rolling time, sec
x_5 = last pass thickness, in.

The relationship between head end finishing temperature and various parameters is shown in equation 5:

$$\log x_6 = 0.516 + 0.716 \log x_4 + 0.142 \log x_7 + 0.108 \log x_8 \quad (5)$$

where:

x_6 = head end finishing temperature, F
x_4 = head end entry temperature, F
x_7 = finishing speed, fpm
x_8 = ordered gage, in.

Equations 6 and 7 allow the coil length to be derived as a function of various finishing train parameters.

$$\log x_9 = 0.0767 + 1.056 \log x_4 + 1.690 \log x_7 - 0.285 \log x_8 - 1.959 \log x_{10} \quad (6)$$

and

$$\log x_9 = 1.602 + 1.918 \log x_6 - 0.0025 \log x_7 - 1.191 \log x_8 - 1.886 \log x_{10} \quad (7)$$

where:

x_9 = coil length, ft
x_4 = head end entry temperature, F
x_6 = head end finishing temperature, F
x_7 = finishing speed, fpm
x_8 = ordered gage, in.
x_{10} = tail end finishing temperature, F

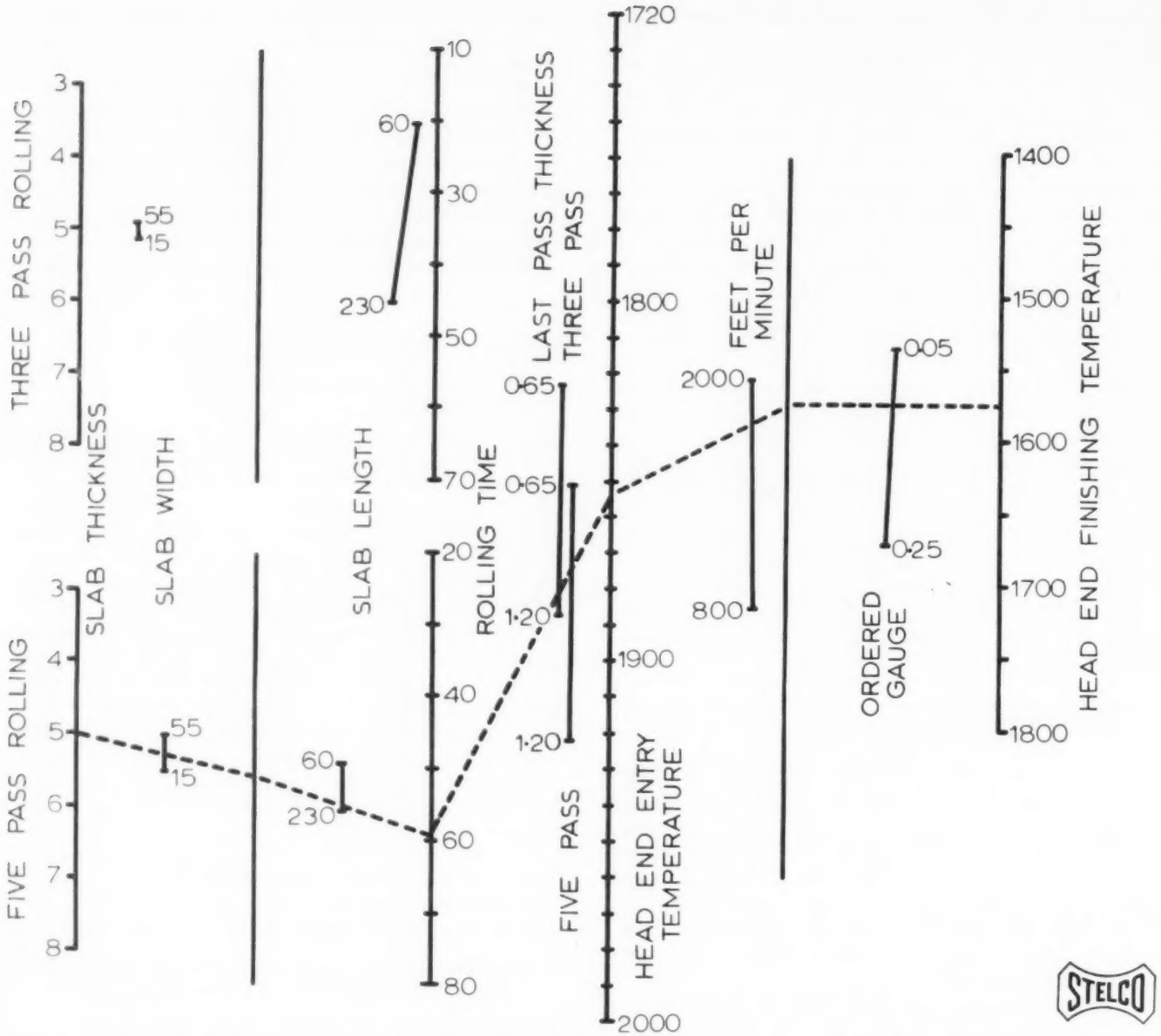


Figure 6 — Nomogram allows the estimation of head and finishing temperature from original slab dimensions.

For the purpose of producing the nomograms, equations 5 and 6 have been combined mathematically to produce equation 8 which expresses the tail end finishing temperature as a function of the finishing train parameters.

$$\log x_{10} = 0.303 + 0.905 \log x_4 + 0.936 \log x_7 - 0.510 \log x_6 - 0.090 \log x_8 - 0.510 \log x_9 \quad (8)$$

Figure 6 shows the nomogram for the estimation of head end finishing temperature derived using equations 2, 3, 4 and 5, while Figure 7 shows the nomogram, based on equations 2, 3, 4 and 8, for the estimation of tail end finishing temperature. An example of the method of using the nomograms is included on each figure.

The nomograms as calculated are representative of conditions existing at the present time in the hot strip mill of The Steel Company of Canada, Ltd., and cannot be applied to other mills. However, the basic method for their derivation could be applied to other mills, resulting in equations of a similar form but with different coefficients.

The nomograms enable predictions to be made for the performance of the mill using the present slab sizes. If the slab size is known and the head end finishing temperature stipulated for a certain product and gage, the nomogram shown in Figure 6 may be used to estimate the finishing speed required to meet this finishing temperature specification. At the same time, the approximate production rate for this slab size can be determined by a simple calculation involving the rolling time on the rougher, if the assumption that the roughing equipment is the pace-setting element of the mill is accepted. Similarly, if the head and tail end finishing temperatures are set, the finishing speed required to meet these specifications can be estimated by using the nomogram shown in Figure 7. The nomograms may also be used for the evaluation of the performance of the mill with slabs resulting from new ingot sizes as these are proposed.

It would be possible to extend the nomograms to cover the operation of the entire mill from the reversing rougher to the coiler pit by a re-evaluation of the equations derived by J. G. Sibakin and G. M. Ikeda[3] in

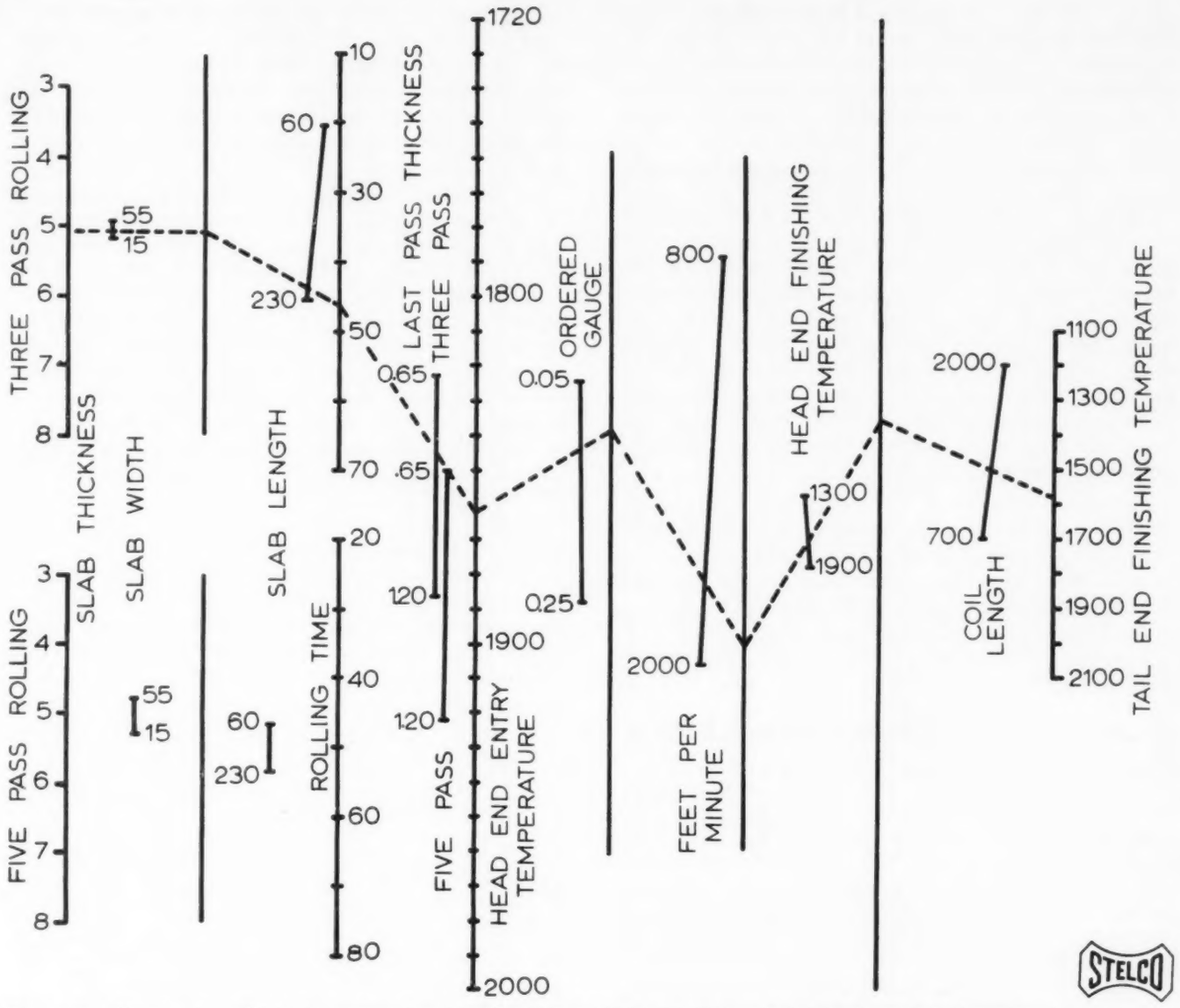


Figure 7 — Nomogram allows the estimation of tail and finishing temperature from original slab dimensions.

their investigation of factors affecting coiling temperature and their addition to the equations listed above.

SUMMARY

1. A method has been derived for the accurate measurement of interstand speeds for the head and tail ends of a coil in the finishing train of a hot strip mill using a cascaded strain gage technique.

2. It is possible to accurately establish the actual drafts taken in each stand by using the measured exit interstand speeds. The average difference between calculated tail end thickness and the tail end thickness as measured in the coiler pit for over 400 coils is −0.004 in.

3. A comparison is made between this accurate method of computing drafts and the method used by the roller in actual operation. For the day-to-day operation of the mill, the roller's method is perfectly acceptable but the more elaborate method would be necessary for theoretical investigations.

4. The relationship between roll separating force and various rolling parameters has been established on an exploratory basis. For a more refined approach to this problem, increased data measuring and logging equipment will be required. The results of such an investigation will be of considerable importance in the establishment of maximum mill productivity in terms of mill settings.

5. The average maximum and minimum values for per cent forward slip have been determined for each stand of the hot strip mill. To measure the precise value of forward slip during the relatively stable conditions occurring after entry and before exit of the coil further data logging equipment would be required.

6. The existence of slip between mating work and back-up rolls has been investigated for one stand of the 56-in. hot strip mill. From a statistical analysis of data collected, it is possible to state that no slip occurs between the work and back-up rolls during the rolling of a coil in this stand.

7. It is possible, from the results of the investigation into slip between mating work and back-up rolls, to determine quite accurately the rate of work roll wear over a period of time. In this case the amount of wear occurring on the back-up roll can be neglected if the time element is short.

8. Nomograms have been developed relating the

rolling practices on the reversing rougher to the operation of the finishing train. They may be used to evaluate the performance of the mill for various rolling schedules and allow an estimate to be made of the production rate for these schedules.

ACKNOWLEDGMENTS

The author wishes to thank The Steel Company of Canada, Ltd., for making possible the present investigation and for permission to publish the results. Thanks are expressed to R. J. Barry, superintendent of the hot strip mill, H. W. Evans, chief roll designer, and N. S. Wells, section head, electrical department, and their staffs, for their support and cooperation throughout the investigation. Thanks are also expressed to J. G. Sibakin, divisional metallurgist, development and special duties division, W. L. Sherwood and D. W. R. George for their valuable assistance.

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3. J. G. Sibakin and G. M. Ikeda, Journal of Metals, vol. 8, No. 9, pp. 1174–81, Sept. 1956.

Discussion

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J. D. Keller: Referring to the nomogram, and the equation, one difficulty is that it is entirely empirical, and there seems to be no way of relating it to the theory of rolling. Secondly, as Mr. Ride has brought out, all the variables in the equation are entirely independent, which actually could hardly be, because you have the speed and percentage reductions inter-related, and the thickness and reduction inter-related, with the rolling speed. So it seems as if there ought to be some inter-connection, some more developed or involved formula to take care of that.

The second point is this matter of wear. The last figures seem to show conclusively that the change in the ratio of the angular roll speeds is directly proportional to the wear—but it is a question of which point we are talking about; to which point along the length does this wear refer? It must be some place near the middle of the roll length, because Mr. Ride mentioned that the roll diameters as measured coincided well with the curve. This would seem to show, then, that what we are talking about is the wear measured at the middle of the length.

On the other hand, Dr. Sachs' findings, from a good bit of the same experimental work showed that the wear at the ends of the backup rolls was at least half as great as the wear at the middle of the length of the backup roll. So how account for that difference? In other words, we seem to be wearing the work rolls in the middle, but we seem to be wearing the backup rolls more or less uniformly all the way along their length. (Of course, most of the work roll wear, however, is caused by the strip.) If it is true, as we believe it to be, that the pressures at the ends are much greater than they are at the middle, then with equal friction coefficients the tangential frictional force ought to be enough to prevent slipping at the ends. In that case, since the diameter ratios are different for the middle and for the ends, there must be slipping between the backup roll and those parts of the work roll near the middle of the length but not near the ends. Yet wear of the backup rolls does occur near the ends also.

It seems that there are factors that have to do with the wear which have not yet been taken into account. A good part of this backup roll wear problem may be a matter of small adhering particles, probably scale, picked up by the work roll and transferred to the backup roll. Such a transfer would seem to be indicated also by the statement in Mr. Wells' paper about the markings from the brush thermocouple, which did not show up on the work roll, but did appear on the backup roll. If that is the case, what is present may be a condition in which the smaller amount of wear at the ends of the backup roll is due to the slipping of fairly smooth surfaces on each other under high pressure, while the larger amount of wear near the middle is due to slippage under less force but with more abrasive material between the surfaces. Further study ought to be given to the mechanism of wear of the backup rolls.

J. V. Latorre: Although Syracuse University played a major role in initiating this test program, the Steel Company of Canada put in considerably more effort in man-hours and dollars than we did. They deserve a lot of credit for their cooperation with the Joint Roll Research Committee and for their contribution of new knowledge.

An item referred on measuring progressive wear on the backup rolls is the problem as to what techniques could be employed in a commercial operating mill to detect "daylight" between the work and backup roll while under load. While this daylight was not possible to detect, our study of progressive wear does shed some light on the subject. In taking contours of the backup rolls at the half way, three quarter and full cycle mark, it appears that wear continues at a reasonably constant rate at the roll center, from the start to the end of a cycle. This means that at least at some time during each work roll cycle, there is bearing on the center portion of the backup roll. However, this does not exclude the possibility that there may be short periods where the center gap is not closed.

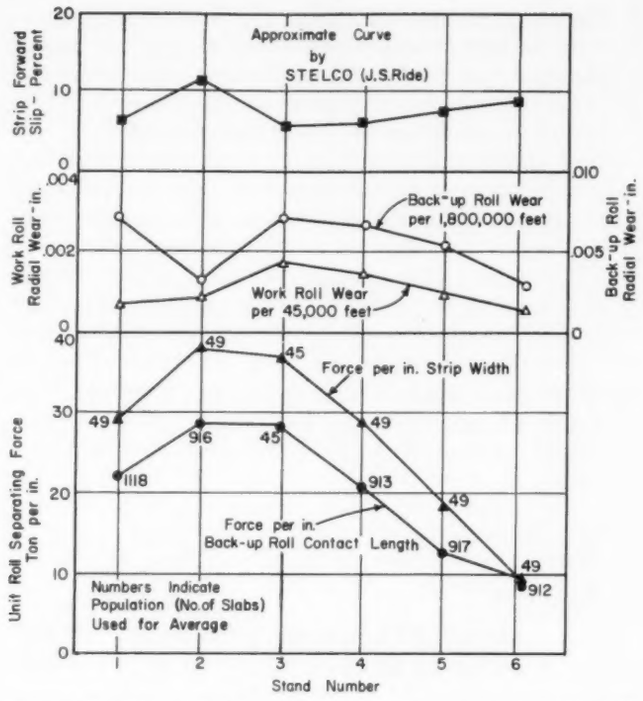

Strip Forward Slip - Percent
Approximate Curve by STELCO (J.S.Ride)
Work Roll Radial Wear - in.
Back-up Roll Wear per 1,800,000 feet
Work Roll Wear per 45,000 feet
Back-up Roll Radial Wear - in.
Unit Roll Separating Force Ton per in.
Force per in. Strip Width
Force per in. Back-up Roll Contact Length
Numbers Indicate Population (No.of Slabs) Used for Average
Stand Number

Figure 8 — Comparison of roll wear, average unit roll separating force and strip forward slip.

Another comment is on Figure 4 which shows a plot of the forward slip in each stand. This may be strictly a coincidence, but this plot has a remarkable resemblance in reverse order, to our plot of the wear of the backup rolls of the same mill (see Figure 8 attached) plotted as a function of strip "mileage." This comparison also holds for wear of the work roll to which strip slip should be more closely related. This may infer that more slip is associated with less wear. This does not sound logical at first thought but does anyone know when or whether the scale which is formed in the finishing train acts as an abrasive or as a lubricant? This makes an interesting study.

R. M. Sills: In connection with his discussion of the calculation of roll separating force the author suggests that the use of an off-line computer to calculate mill settings may be more desirable than an on-line computer. This is possible, but the subject merits some consideration at this time.

The off-line computer has one advantage only (other than possible lower cost, which could well prove to be an insignificant advantage), this is freedom from real time limitations, and the consequent ability to use highly sophisticated and time-consuming computational methods in order to achieve high accuracy.

This possible advantage could be more than offset by the following advantages of an on-line computer:

1. Since its computations are made at the last possible moment, for the slab then on the entry table, the possibility of using an incorrect schedule due to an order change or other mix-up, is reduced.

2. It makes it possible to use actual measurements of slab dimensions and temperature in calculating mill setup, rather than nominal or supposed values.

3. Since the on-line computer normally has adequate capacity for data logging, it can be used to obtain the process information necessary to make accurate calculations, both initially and at any later time when changes dictate the need.

4. Perhaps most important of all, the on-line computer provides the possibility of continuously correcting and improving on its own program to achieve the highest possible accuracy in mill setup.

The expected benefits to be gained through use of an on-line computer include greater scheduling flexibility, shorter mill setup time, fewer cobbles and greatly expanded production records and process knowledge. It does not seem to me that an off-line computer would be able to provide as many benefits.

John S. Ride: With regard to the remarks about the roll force equation and the resulting nomogram, the fact that it is entirely empirical is of great advantage if it is to be used in industry. The various "classical" rolling formulae are far too cumbersome and contain parameters that, in actual practice, are virtually unmeasurable. Thus if an equation can be derived which may predict the roll separating force with a reasonable degree of accuracy, using measurable parameters, surely this equation would be of value, even if there seems to be no way of relating it to rolling theory. Perhaps I did not make myself clear when I was talking of the relationships between the chosen parameters. There is a tremendous degree of interdependence between the parameters, which tends to produce a rather distorted picture when the parameters are plotted separately against the roll separating force.

Mr. Keller's points concerning the relationship between angular roll speeds and the progressive rate of work roll wear are well taken. When it was stated that the pulse tachometers could be used to measure the progressive rate of work roll wear, the roll diameters used were those normally taken by the roll grinders, i.e., they were taken at the center of the work roll length. Thus we are talking about the rate of wear at the center of the work roll length, assuming that the wear on the backup roll is constant and negligible over the period of time in question. If we abstract some test figures, the average radial wear at the center of the length of the top backup roll in No. 5 stand is 0.020 in. while that at the ends is 0.010 in. after 19 turns. From this data, the average amounts of radial wear at the center and ends after one turn are approximately 0.001 in. and 0.0005 in. respectively. Thus the assumption that wear on the top backup roll in No. 5 stand is constant and negligible can be considered as legitimate.

It has been pointed out by Mr. Keller that, although there are no differences in angular velocities between work and backup rolls because of slip, there may be differences in peripheral speed along their length because of differences in distance from the axis of rotation to the roll periphery. These differences, resulting largely from the center wear pattern of the work roll, could possibly explain the fact that backup roll center wear is approximately twice the end wear. This hypothesis may be supported by the fact that in No. 1 and 2 stands, where work roll wear is uniform backup roll wear is also uniform. If scale pick-up were the primary cause of backup roll wear, would not the wear be greater in the areas within the strip width, i.e., on the center portions of the backup rolls? However, Mr. Keller's theory of scale pick-up is supported, to some extent, by our experiences with the brush thermocouples.

Mr. Latorre's question as to whether the secondary scale formed during rolling in the finishing train acts as an abrasive or as a lubricant at the existing temperatures is a very important one and must be answered if Mr. Keller's theory is to be proved correct or not.

Both Mr. Keller and Mr. Latorre comment on the lack of knowledge regarding the mechanism of backup roll wear. It is to be hoped that, in the near future, someone with the time and experience will concentrate on this problem and that they will provide a satisfactory explanation of how backup roll wear occurs.

N. S. Wells: The off-line computer approach as suggested here provides a logical intermediate stage in the development of full mill control. Once correctly programmed, the computer functions as a mill simulator enabling detailed studies to be made of various aspects of the complete process—with the freedom from real time limitations mentioned by Mr. Sills. No substantial equipment expenditures are necessary at this point and the economies liable to be produced by the installation of an on-line computer can also be investigated.

Card programmed reversing roughers feeding hot strip mill finishing trains are now in operation without any particular scheduling problems. This programmed approach can be extended to the finishing train using listed optimised mill settings generated by the off-line computer, with the mill still being set manually. This latter point is of some interest to mill production staff as under these circumstances the mill roller does not loose his acquired rolling skill. In fact it would seem that his rolling skill and knowledge could be substantially increased with corresponding production benefits. ▲

Instrumentation for Hot Strip Mill Test Program

by N. S. WELLS,
Section Head—Application,
Special Controls and Drives
Electrical Dept.
The Steel Co. of Canada, Ltd.
Hamilton, Ontario, Canada

The results of a research project depend upon dependable and accurate instrumentation . . . . a number of novel and ingenious procedures were developed for the hot strip mill research program.

THE Steel Company of Canada was one of several steel companies participating in the Roll Spalling and Wear Investigations instigated by the Joint Roll Research Committee of the Association of Iron and Steel Engineers and the Roll Manufacturer's Institute. In addition to the work involved in this program, The Steel Company of Canada carried out a parallel project[1]* to obtain additional information on significant mill rolling parameters in order to supplement extensive studies previously carried out on this mill. A considerable amount of work was involved in the design and installation of the instrumentation necessary to carry out these programs[2].

The hot strip mill at the Hamilton plant of the Steel Company of Canada consists of a 4-high, 110-in. reversing rougher feeding steel to a six-stand 4-high, 56-in. mill finishing train. These stands are powered by five 3500-hp drive motors on stands No. 1 through 5 and a 3000-hp motor on stand No. 6. All these motors are supplied from a common 600-volt, d-c bus fed from four 3500-kw generators in parallel. Figure 1 shows the general arrangement of the mill and the location of the monitored variables.

The test requirements for the roll spalling and wear program covered the following measurements:

1. Stand roll separating force.
2. Drive electrical loads.
3. Drive motor speeds.
4. Work roll surface temperature.
5. Determination of slip between mating work and backup rolls.

The first four items were to be obtained for stands No. 2 and 5 and the last item for No. 5 only. Items 2 and 3 were monitored from existing sensors. Due to the amount of equipment used during the various phases of these tests it was important that a suitable central test location be provided. Fortunately space was available below the strip mill operators pulpit and it was possible to concentrate all the test equipment at this point. Visual observation of the mill was available from here, also loud speaker communication to the whole mill. All incoming cables were terminated at connection blocks and the desired variables could be

* Numbers in parentheses refer to Bibliography at end of paper.

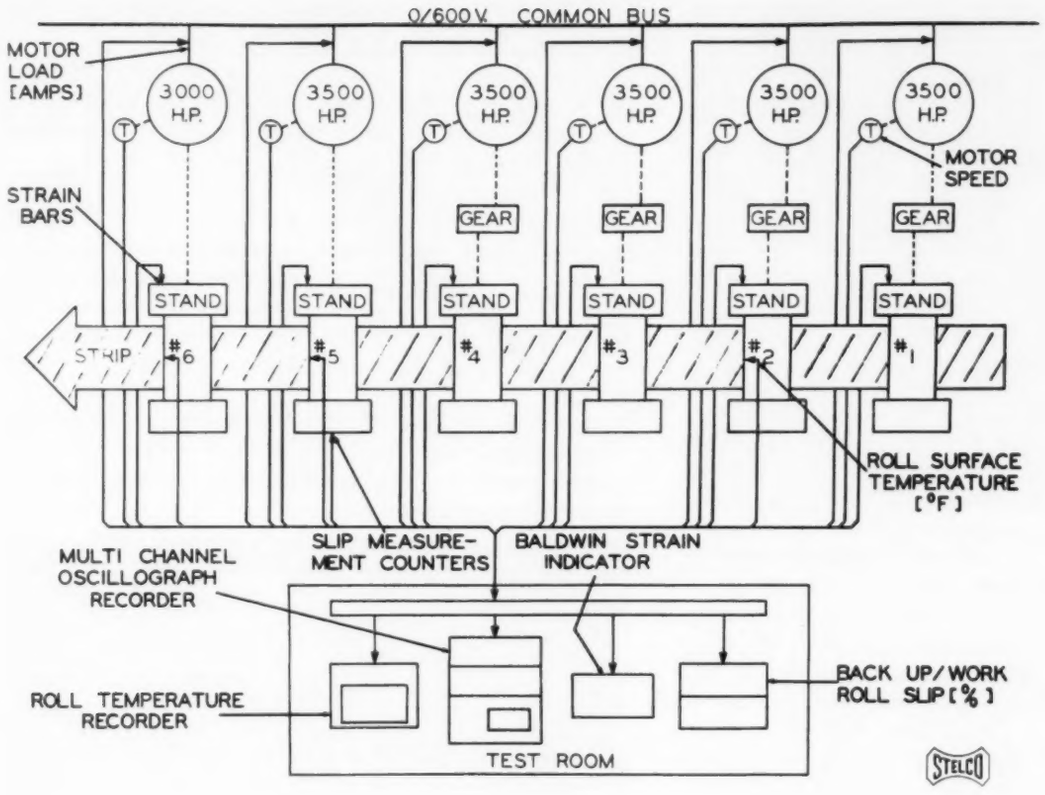


Figure 1 — Mill arrangement shows locations of data measured.

connected as required to the recording equipment. Figure 2 shows part of the test room.

The major work involved in this whole test program was in connection with the individual stand roll separating force measurements. It was accepted that load cells mounted under the screws for roll force measurement would provide the best results, but the cost was prohibitive. Previous work carried out on another Steel Company of Canada mill using direct bonded resistance strain gages pointed to the desirability of a strain multiplying type of unit in order to provide an adequate signal level. Such a unit had to be capable of relatively simple attachment to mill housings. On this basis one of our suppliers developed the type of bolted unit shown in Figure 3—using a knife edge forced into the housing section to provide accurate

Figure 2 — Test house interior was crowded with equipment.

fixed gage length points. The complete assembly is shown in Figure 4. The bar on the right was a mounting jig which was removed after the strain bar assembly was complete. The actual strain measuring element consisted of a specially shaped $\frac{1}{64}$-in. thick ground tool steel strain wafer (Figure 5) necked to $\frac{3}{8}$-in. width, at the point of maximum strain concentration. The measuring strain gages were bonded to the wafer here, plus the temperature and bending compensating gages. Steel blocks were brazed to each end of this strain wafer to facilitate clamping to each half of the strain multiplying bars, and giving a total gage measuring length of 25 in. This type of construction was used to permit the simple removal of the strain wafer.

It appeared that a bolted type strain gage unit would be of use for various other applications and that it was worth additional test effort to prove such a unit. Each strain bar was tested in the metallurgical laboratory using the 300,000-lb tensile testing machine with the strain measuring unit mounted on a $1\frac{1}{2}$-in. square test bar. This was preloaded to 10,000 lb to avoid any possible bending effects due to the testing machine clamps and the strain bar was then clamped down. Loads of up to 15,000 lb were then applied. Calibration curves were obtained in this fashion for each bar with the results given in Figure 6.

An electric resistance strain indicating unit was used for these tests. All the calibrations were linear with some spread between individual units. Each unit was without hysteresis and random loads would always produce readings coinciding with the particular calibration curve. These tests were carried out under near ideal controlled conditions. The signal level obtained from the strain gages was obviously high enough to permit a high order of accuracy when using the indicating unit. Only two tapped $\frac{3}{8}$-in. strain bar mounting

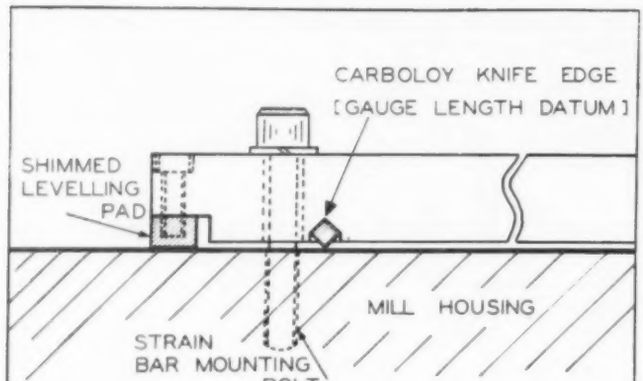


Figure 3 — Strain bar knife edge detail was developed by supplier.

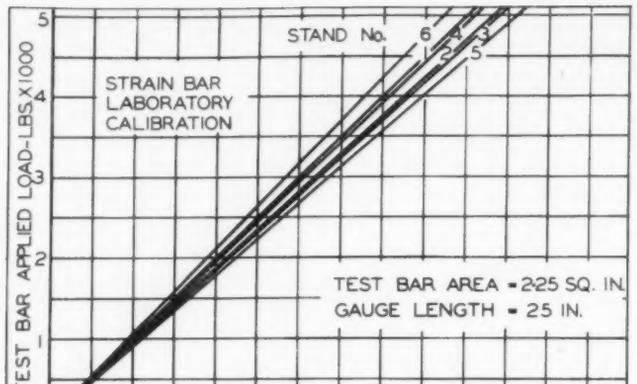


Figure 6 — Strain bar laboratory calibrations were obtained ahead of time.

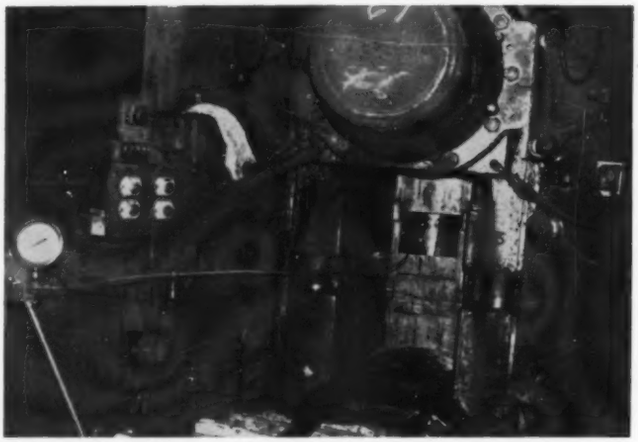


Figure 7 — Mill housing was calibrated in advance.

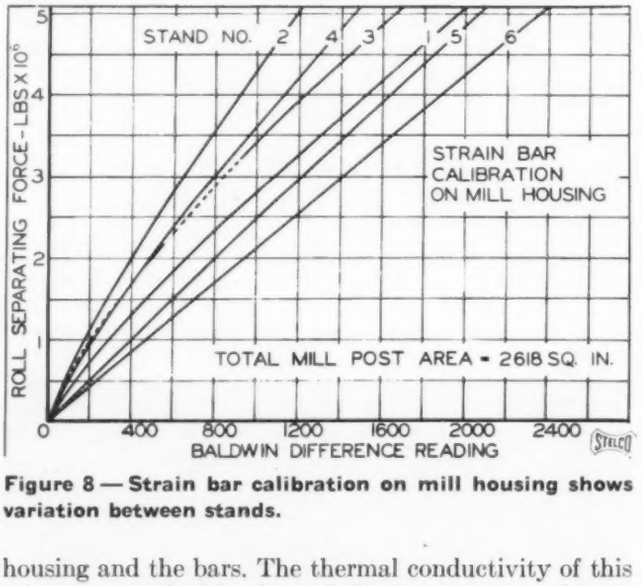


Figure 8 — Strain bar calibration on mill housing shows variation between stands.

bolt holes were required on each mill housing. Because of the use of knife edges and the small clearance between the face of the strain bars and the mill housing, it was necessary to have a reasonably smooth housing mounting surface. An area of approximately 30 by 3 in. had to be ground smooth on each rough cast steel housing. The strain bar was located as close as possible to the neutral axis of the mill housing post in order to minimize bending effects in the plane parallel to the roll axes.

The mill housing temperature slowly changes during mill down shifts depending on the ambient temperature and the prior mill rolling conditions. There then exists the problem of ensuring that the strain wafer has sufficient pretension applied to remove nonlinear effects due to possible changes from compressive to tensile stresses. One-half of the strain bar was therefore heated to a temperature approximately 10 F above that of the other half bar and the strain wafer clamped into position. This provided a satisfactory level of prestrain. The difference in temperature between the mill housing and the strain bar is also of considerable importance, any difference producing a fictitious housing loading. To ensure good heat conduction between the housing and the strain bars, an aluminum loaded grease was forced in the gaps between the housing and the bars. The thermal conductivity of this mixture was double that of the base grease without significant change in its electrical resistance. The complete strain bar unit was then submerged in high temperature grease. This again was an aid to thermal conduction from the housing to the bars. Its main function, however, was to act as a barrier to external moisture and reduce the effects of ambient temperature conditions. This layer of grease was built up to completely fill an inner enclosing steel case, gasketed at its point of contact with the mill housing and bolted to it.

Figure 4 — Strain bar is mounted on mill housing.

Figure 5 — Strain wafer is actual measuring element.

This provided a measure of mechanical protection to the enclosed strain bars and strain wafer. A neoprene sheet mounted in the face of this inner steel case provided relief for any expansion taking place in the grease filling. The neoprene sheet had a raised protective steel cover over it, open at the top and bottom. A final external steel cover completed the strain bar assembly. This cover was lined with glass wool in a further effort to provide stable temperature conditions.

A 5,000,000-lb hydraulic jack interposed between the backup rolls was used to calibrate each stand strain bar. Contoured brass liners on the top and bottom spacers transmitted the jack thrust via the backup rolls to the screws to produce the calibrating strain in the housing posts. Hydraulic jack operating pressures of up to 23,000 psi were used. These pressures were provided by the hand operated hydraulic pump visible on the left of Figure 7. The jack assembly is visible between the backup rolls, also the angle guides used to slide the jack into its position on the axial centre of the backup rolls. The maximum stand roll separating force specified by the mill builders was 2500 tons and all testing was done well below this figure. Hand pumping during the whole calibration period would have taken a considerable amount of time. This was quite impracticable as all calibrations were carried out under minimum time conditions during mill down shifts sandwiched between roll changes and other essential mill maintenance. The technique adopted was therefore to hand pump until the pressure gage registered. Thereafter all housing loads were obtained by operating the mill screws.

The strain bar calibrations for all mills are shown in Figure 8 revealing a very wide spread between individual stand results. Apart from No. 6 stand all calibrations are curvilinear in form. This is attributed principally to initial misalinement of the bar in either the vertical or horizontal plane, plus some rolling action on the strain bar knife edges. Although considerable care and attention was exercised during these installations, it must be noted that the *total strain* appearing across the knife edges would only be of the order of 0.00075 in. for 1250 tons total roll separating force, hence minute secondary movements could produce considerable variations in the calibration curves for different units.

In spite of the precautions taken to ensure good temperature conduction between the housing and the bar, and its isolation from external ambient effects, it was very obvious during these calibrations that a changing temperature differential existed at all times between the strain bar and housing. This produced a slow drift of the unloaded strain bar output signal. It was therefore, necessary to obtain a zero load strain gage reading for each load value throughout the whole test sequence. Resulting difference readings were used for deriving the calibration curves. The same technique was used for obtaining the actual mill loads at a later date. One additional use was made of the strain bars by utilizing a simple strain gage paralleling technique. It was then possible to produce a single channel recording oscilloscope display for all roll forces. Using a fast time base, the interstand strip gages and speeds could then be accurately established.

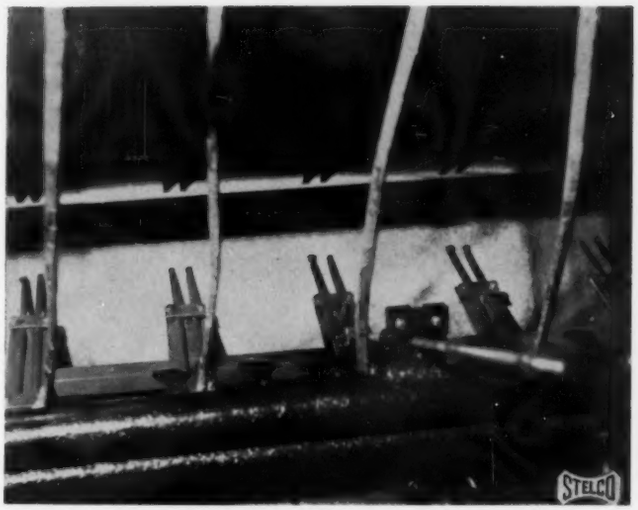


Figure 9 — Brush thermocouples were used to measure work roll temperature.

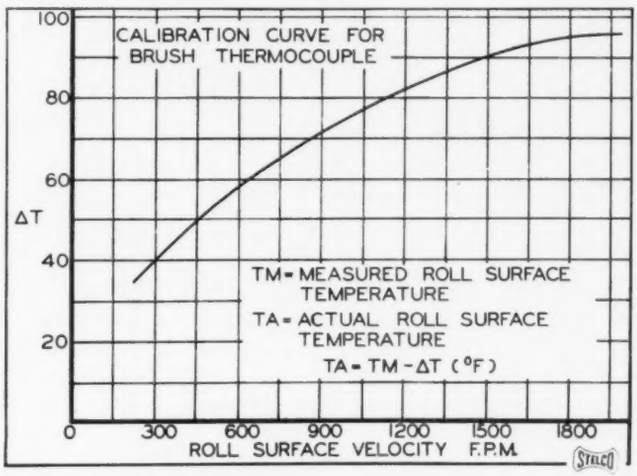


Figure 10 — Brush thermocouples require a roll speed correction curve.

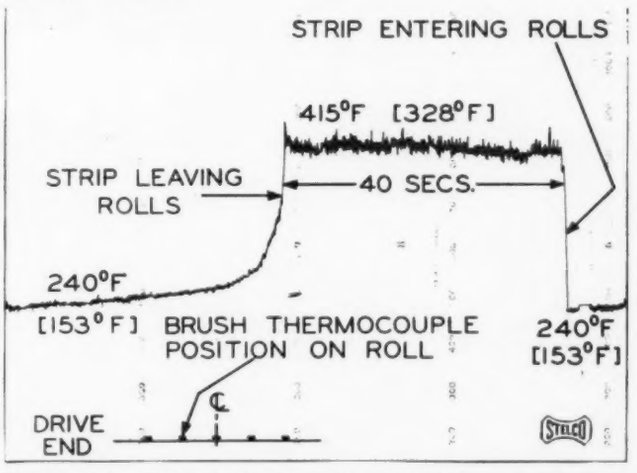


Figure 11 — Typical brush thermocouple temperature record.

Initially an attempt was made to measure roll surface temperatures using a special bolometer type infrared pyrometer, but steam conditions plus a polished roll surface combined to reflect the hot strip's radiation rather than give a true measure of roll surface temperature. Finally these temperature measurements were made using brush thermocouples previously developed by the research department of the Bethlehem

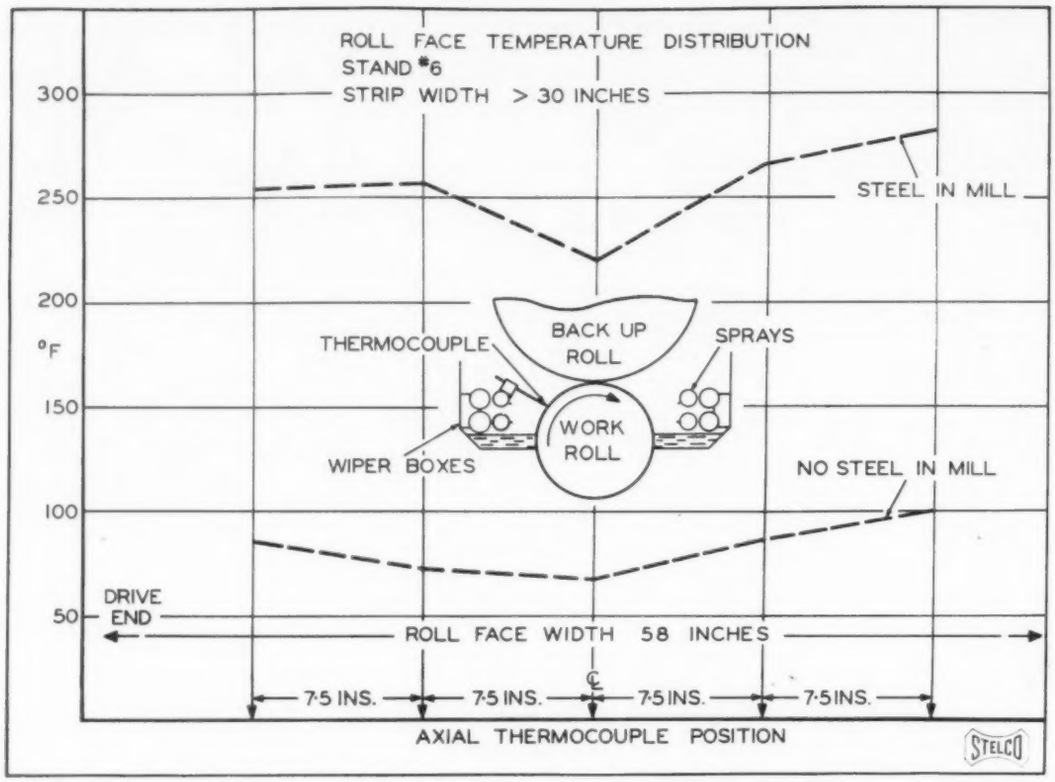


Figure 12 — Roll temperature distribution across roll when rolling wide strip.

Steel Co.[3]. Each thermocouple consisted of two brushes, one made with iron bristles, the other with constantan. These two brushes were located against the iron roll about 1 in. apart. The point of temperature measurement was the contact area between the iron roll and the constantan brush, with the iron brush completing the iron circuit to the cold junction in the potentiometer recorder.

Special thermocouple mounting brackets and assemblies were designed for this application, the complete unit fitting inside the wiper box on the exit side of the mill. A hinged mounting with spring back tension held the thermocouple brushes against the work roll surface. The center thermocouple was arranged to be on the axial center line of the work roll with the other two units being 15 in. on either side. Tests were also run using a five-thermocouple assembly, with a 7½-in. thermocouple spacing. Figure 9 shows the complete assembly in position. It was established that there was a significant error in the indicated temperature due to brush-roll surface friction producing localized heat. Special calibration runs were carried

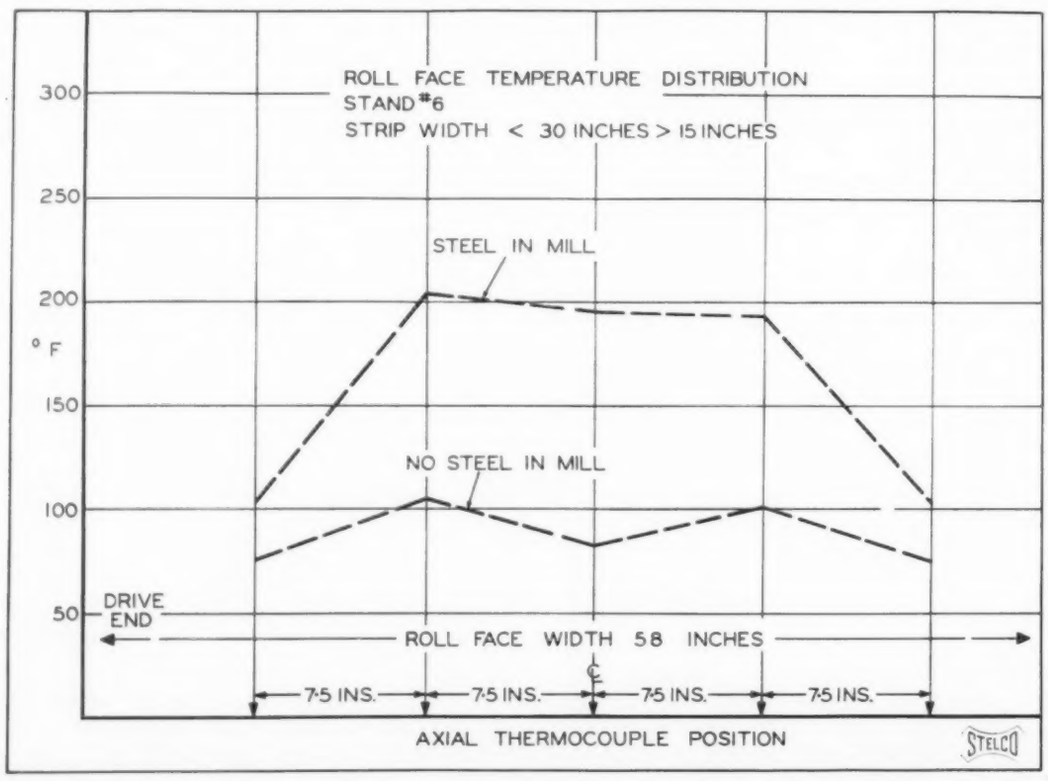


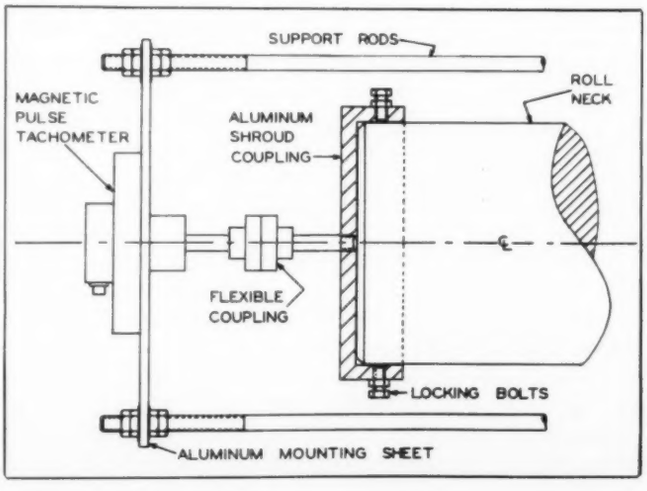
Figure 13 — Roll temperature distribution across roll when rolling narrow strip.

out on a single stand and the indicated temperature was obtained for a number of different roll peripheral velocities. After each measurement the mill was stopped and the roll surface temperature checked at the same point on the roll with a contact pyrometer. For this condition the indicated and measured temperatures were found to be identical. These tests were repeated for various thermocouple roll contact pressures and different water spray conditions. From these results it was possible to produce the calibration curve Figure 10. Figure 11 shows a typical temperature record for a single thermocouple during the passage of a bar through the mill. The chart speed was 8 in. per min and the indicated temperature is half the scale reading. The bracketed figures are the true temperatures corrected using Figure 10. Typical results showing the actual temperatures across the roll face are given in Figures 12 and 13. The former is for a five-thermocouple assembly when rolling strip wider than 30 in. Figure 13 gives similar values for strip between 15 and 30 in. wide.

An accurate method of measuring roll slip between the mating work and back-up rolls on a single stand was required. Digital techniques appeared to offer the best chances of producing accurate results. Based on the assumption of no slip between work and backup rolls the speed ratio between the two rolls should be constant. It was, therefore, proposed to use two counters accumulating counts from pulse tachometers attached to each roll and gated over the same time period. The two pulse trains were fed into two 4 decade electronic counters of the dekatron type which had been extended to ten decades by the addition of separate mechanical counters to each unit.

The two electronic counters were gated electronically so that simultaneous stop and start of both units was obtained on receipt of a remote manually operated command signal. The accuracy of the tests obviously depended on this electronic gate, and it was, therefore, necessary to provide some check on this coincident stop-start feature during an extended test period. This was accomplished by feeding both pulse signals to a plug box capable of either feeding independently straight through to each counter or feeding the pulse train from a single pulse tachometer to both counters. For this condition identical counts would be obtained

Figure 14 — Pulse tachometer mounting presented problems.



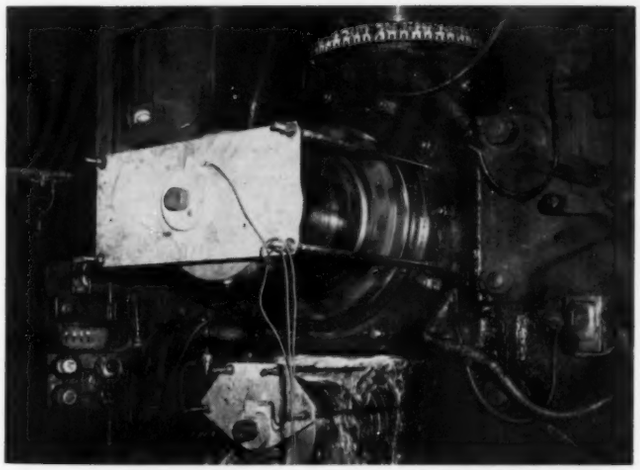


Figure 15 — Arrangement of pulse tachometers on mill.

on both counters—if the gate was operating correctly. Magnetic type pulse tachometers were used giving 600 counts per work roll revolution and 1000 counts per backup roll revolution. These provided approximately 8 and 7 counts respectively per roll peripheral inch which provided a sufficiently high measuring accuracy.

The mounting of these tachometers posed many problems. It is always difficult to couple an instrument type drive to something very large such as a mill roll, particularly when the whole assembly has to be capable of fast removal when roll changes occur. Also mill rolls are ground from their own bearing surfaces and in general accurate roll end centers are usually not available. To overcome these problems the arrangement shown in Figure 14 was used. A 2-in. axial surface was ground at the mill end of the roll during normal roll shop surface dressing. A close fitting aluminum shroud type coupling was mounted on this specially prepared surface and bolted firmly in position. This had a true center jack shaft which was coupled through a small flexible coupling to the pulse tachometer. This in turn was mounted on a sheet aluminum panel supported by four threaded rods inserted into existing holes in the roll chocks. The complete assembly is shown in Figure 15. This mechanical arrangement proved to be entirely successful.

Any investigation carried out in an operational steel mill inevitably involves many people of diverse skills and knowledge. Many groups were involved in this project including—electrical, mechanical, metallurgical, plant utilities, and roll design staff. The work described here represents the results of their combined knowledge and experience. This test program involved many abnormal demands on the plate and strip mill production and maintenance personnel. Without their complete understanding and co-operation much of the program would not have been possible. ▲

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1. "Analysis of Operational Factors Derived from Hot Strip Mill Tests," by John S. Ride, AISE Spring Conference April 25, 1960, and November, 1960, *Iron and Steel Engineer*, pp. 77–90.
2. "Investigation of Rolling Parameters on a 56-In. Hot Strip Mill," A Steel Company of Canada Ltd. Film Production (50 minute black and white sound film).
3. "Roll Temperature Study on a Hot Strip Mill," by A. M. Belansky and C. F. Peck, 1956 Proceedings AISE. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Friday, December 9, 1960
Christmas Dinner and Dance
Social Hour 6:30 P.M.
Dinner 7:30 P.M.
Dancing 9:00 P.M. to 12 M.
Redmont Hotel, Birmingham, Ala.

BUFFALO SECTION

Saturday, December 10, 1960
Christmas Dinner and Dance
Social Hour 7:30 P.M.
Dinner 8:00 P.M.
Dancing 9:00 P.M. to 1:00 A.M.
Golden Ballroom, Hotel Statler Hilton, Buffalo, N. Y.

CANTON SECTION

Saturday, December 10, 1960
Christmas Dinner and Dance
Social Hour 7:00 P.M.
Dinner 8:00 P.M.
Dancing 9:00 P.M. to 1:00 A.M.
Mergus Restaurant, Canton, Ohio

CHICAGO SECTION

Saturday, December 3, 1960
Christmas Dinner and Dance
Dinner 7:00 P.M.
Sheraton Hotel, Chicago, Ill.

CLEVELAND SECTION AND YOUNGSTOWN SECTION

Saturday, December 3, 1960
Dinner 7:30 P.M.
Cleveland Engineering & Scientific Center
3100 Chester Avenue, Cleveland, Ohio

COLORADO SECTION

Tuesday, December 20, 1960
Dinner Dance
Minnequa Club, Pueblo, Colo.

DETROIT SECTION

Saturday, December 10, 1960
Christmas Dinner and Dance
Social Hour 6:30 P.M.
Dinner 7:30 P.M.
Dancing 9:00 P.M. till?
Detroit Yacht Club, Belle Isle, Detroit, Mich.

LOS ANGELES SECTION

Saturday, December 3, 1960
Christmas Dinner and Dance
Social Hour 6:30 P.M.
Dinner 8:00 P.M.
Dancing—until?
Statler Hilton Hotel, Los Angeles, Calif.

PHILADELPHIA SECTION

Saturday, December 3, 1960—Dinner 6:00 P.M.
Meeting 7:00 P.M.
Lukens Electric Melt Shop

"Building Layout and Facilities," by W. W. Bintzer, Civil Project Engineer, Engineering and Construction Div., Lukens Steel Co., Coatesville, Pa.

"Substation Design, Layout, and Synchronous Condenser," by W. C. Clark, Utilities Project Engineer, Engineering and Construction Div., Lukens Steel Co., Coatesville, Pa.

"Furnace Mechanical and Electrical Characteristics," by E. B. Smith, Electrical Superintendent, Maintenance Div., Lukens Steel Co., Coatesville, Pa.

"Operations," by C. H. Alexander, Superintendent of Melting, Lukens Steel Co., Coatesville, Pa.

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.

PITTSBURGH SECTION

Saturday, December 10, 1960
Christmas Dinner and Dance
Dinner 8:00 P.M.
Dance 9:00 P.M.
Penn-Sheraton Hotel, Pittsburgh, Pa.

ST. LOUIS SECTION

Saturday, December 3, 1960
Christmas Dinner and Dance
Dinner 7:00 P.M.
Dancing 9:00 P.M. to 1:00 A.M.
Stratford Hotel, Alton, Ill.

SAN FRANCISCO SECTION

Saturday, December 3, 1960
Christmas Party
Social Hour 7:00 P.M.
Dinner 8:00 P.M.
Dancing 9:00 P.M.
Mt. Diablo Country Club, Danville, Calif.

UTAH SECTION

Friday, December 2, 1960
Christmas Party 6:30 P.M.
Salt Lake City Country Club, Salt Lake City, Utah

Proposed Bearing Sections for AISE EOT Crane Specifications

by ROSS B. McCREADY,
Chairman,
Subcommittee on Crane Bearings

and I. E. MADSEN,
Research and Standards Engineer
AISE

SINCE the last edition of the AISE Specifications for Electric Overhead Traveling Cranes for Steel Mill Service—AISE Standard No. 6, there have been a number of bearing developments, numerous changes in published bearing ratings and extensive work on bearing standardization by the Anti-Friction Bearing Manufacturers Association. Therefore the AISE Crane Committee, which is now working on the revision of the crane specifications, under the chairmanship of R. L. Livingston, chief electrical engineer of the United States Steel Corp., appointed a subcommittee on bearings under Ross B. McCready as chairman. This committee has worked with a number of bearing manufacturers to develop the following draft standard. The values in the standard have been checked with these manufacturers and approved by them. This draft is now being submitted to the over-all crane committee for adoption, and is being published here in an effort to obtain comments and criticisms both favorable and unfavorable.

The proposed specification differs from the current standard in a number of ways. It is much shorter and has been simplified. Bearings are not related to any particular manufacturer or catalog rating. AFBMA nomenclature and dimensions have been used but ratings are not necessarily AFBMA ratings.

Bearings are classified as heavy, medium and light duty as opposed to the 15 classifications previously used. Since life classifications are a function of the number of cycles determined from hours of life and speed, the total cycle rating is included so the table may be applied to any combination of speed and time. A larger number of ratings is not needed since the spread in ratings usually covers a number of cycle-speed combinations so the same bearing would be used for a number of applications.

In proposed standard it will be noted that bearings usually change one size for the three duty classifications adopted and also one size when going from one box load to the next in the table. Also the heavy duty bearing for a particular load is often the medium or light duty bearing for the next higher load. These size changes check the logic of the life classifications and box loads selected. This also reduces number of bearing sizes needed and inventory. Unfortunately, shaft stresses often upset this step pattern in the bearing selections.

Bearings were selected on assumption that shaft stress is 8000 psi. Shaft materials with higher strengths could be used if bearing bore should be cut down.

The box load is listed on the table and was used for computing shaft sizes. Bearing load was based on 75 per cent box load. An application where box load is constant or always higher than 75 per cent box load would require a larger bearing than given in table. The table can still be used by selecting the bearing listed for the box load in the table which is equal to the maximum actual box load times the ratio of average value to 75 per cent maximum load.

The AFBMA reference number is listed first in Table 34-1. Since many designers and users are not yet familiar with these numbers, a reference number is listed which is that conventionally used up to now by designers. Eventually this reference number will probably be dropped.

This draft is still tentative and there may be future revisions before final adoption. Comments and criticisms are invited. Please report any errors. Such comments should be sent to AISE, 1010 Empire Building,

TABLE 34-I
Bearings for Bridge and Trolley Track Wheel Axles

Box load, lb		Spherical Bearings			Tapered Bearings			Straight Bearings		
		Heavy duty, 240,000,000 cycles (40,000 hr-100 rpm)	Medium duty, 144,000,000 cycles (40,000 hr-60 rpm) (24,000 hr-100 rpm)	Light duty, 60,000,000 cycles (10,000 hr-100 rpm) (20,000 hr-50 rpm) (40,000 hr-25 rpm)	Heavy duty, 240,000,000 cycles (40,000 hr-100 rpm)	Medium duty, 144,000,000 cycles (40,000 hr-60 rpm) (24,000 hr-100 rpm)	Light duty, 60,000,000 cycles (10,000 hr-100 rpm) (20,000 hr-50 rpm) (40,000 hr-25 rpm)	Heavy duty, 240,000,000 cycles (40,000 hr-100 rpm)	Medium duty, 144,000,000 cycles (40,000 hr-60 rpm) (24,000 hr-100 rpm)	Light duty, 60,000,000 cycles (10,000 hr-100 rpm) (20,000 hr-50 rpm) (40,000 hr-25 rpm)
1,000	Bore, in. AFBMA No. Ref No.	1.5748 40**22 22208	1.5748 40**22 22208	1.5748 40**22 22208	1.375 LM48548-LM48510	1.375 LM48548-LM48510	1.375 LM48548-LM48510	1.1811 30RM03 1306	1.1811 30RM03 1306	1.1811 30RM03 1306
3,000	Bore, in. AFBMA No. Ref No.	1.5748 40**22 22208	1.5748 40**22 22208	1.5748 40**22 22208	1.7812 LM603049-LM603011	1.7812 LM603049-LM603011	1.7812 LM603049-LM603011	1.5748 40RM03 1308	1.5748 40RM03 1308	1.5748 40RM03 1308
5,000	Bore, in. AFBMA No. Ref No.	1.9685 50**23 22310	1.9685 50**23 22310	1.9685 50**22 22210	2.250 387-382	2.250 387-382	2.250 387-382	2.1654 55RM32 5211	1.9685 50RM32 5210	1.9685 50RM32 5210
7,000	Bore, in. AFBMA No. Ref No.	2.3622 60**23 22312	2.3622 60**23 22312	2.3622 60**22 22212	2.625 29590-29520	2.625 395S-394AS	2.625 395S-394AS	2.5591 65RM32 5213	2.3622 60RM32 5212	2.1654 55RM32 5211
9,000	Bore, in. AFBMA No. Ref No.	2.5591 65**23 22313	2.5591 65**23 22313	2.5591 65**22 22213	2.6875 33269-33462	2.6875 33269-33462	2.6875 399A-394AS	3.1496 80RM32 5216	2.7559 70RM32 5214	2.5591 65RM32 5213
10,000	Bore, in. AFBMA No. Ref No.	2.5591 65**23 22313	2.5591 65**23 22313	2.5591 65**22 22213	2.875 33287-33462	2.875 33287-33462	2.875 29685-29620	3.3465 85RM32 5217	2.9523 75RM32 5215	2.5591 65RM32 5213
12,000	Bore, in. AFBMA No. Ref No.	2.9258 75**23 22315	2.9258 75**23 22315	2.9258 75**23 22315	3.500 593-592A	3.500 593-592A	3.500 593-592A	3.5433 90RM32 5218	3.3465 85RM32 5217	2.9528 75RM32 5215
15,000	Bore, in. AFBMA No. Ref No.	3.1496 80**23 22316	3.1496 80**23 22316	3.1496 80**23 22316	3.750 594-592A	3.750 594-592A	3.750 594-592A	3.7402 95RM32 5219	3.5433 90RM32 5218	3.1496 80RM32 5216
18,000	Bore, in. AFBMA No. Ref No.	3.5433 90**23 22318	3.5433 90**23 22318	3.5433 90**23 22318	4.000 687-672	3.750 594-592A	3.750 594-592A	4.1339 100RM32 5221	3.7402 95RM32 5219	3.5433 90RM32 5218
20,000	Bore, in. AFBMA No. Ref No.	3.5433 90**23 22318	3.5433 90**23 22318	3.5433 90**23 22318	4.000 780-772	4.000 687-672	3.750 594-592A	4.3307 110RM32 5222	3.9370 100RM32 5220	3.5433 90RM32 5218
24,000	Bore, in. AFBMA No. Ref No.	3.9370 100**23 22320	3.9370 100**23 22320	3.9370 100**32 23220	4.500 71450-71750	4.500 64450-64700	4.000 52400-52618	4.7244 120RM92 5224	4.3307 110RM32 5222	3.7402 95RM32 5219
30,000	Bore, in. AFBMA No. Ref No.	4.3307 110**23 22322	4.3307 110**23 22322	4.3307 110**23 22322	5.000 67388-67322	5.000 67388-67322	4.500 64450-64700	5.5118 140RM92 5228	5.1181 130RM92 5226	4.1339 105RM32 5221
40,000	Bore, in. AFBMA No. Ref No.	4.7244 120**23 22324	4.7244 120**23 22324	4.7244 120**32 23224	5.500 71425-71750	5.500 71425-71750	5.5250 71425-71750	6.2992 160RM92 5232	5.9055 150RM92 5230	5.5118 140RM92 5228

40,000	Bore, in. AFBMA No. Ref No.	4.7244 120**23 22324	4.7244 120**23 22324	4.7244 120**23 22324	5.500 898-892	5.500 898-892	5.5250 67390-67322	6.2992 160RM92 5232	5.9055 150RM92 5230	5.5118 140RM92 5228
50,000	Bore, in. AFBMA No. Ref No.	5.5118 140**23 22328	5.5118 140**23 22328	5.5118 140**32 23228	6.000 99600-99100	6.000 99600-99100	6.000 99600-99100	6.6929 170RM92 5234	5.9055 150RM92 5230	5.5118 140RM92 5228
60,000	Bore, in. AFBMA No. Ref No.	5.9055 150**23 22330	5.9055 150**23 22330	5.9055 150**32 23230	6.500 HM237535-HM237510	6.500 HM237535-HM237510	6.500 99649-94113	7.4803 190RM92 5238	6.6929 170RM92 5234	6.2992 160RM92 5232
70,000	Bore, in. AFBMA No. Ref No.	6.6929 170**23 22334	6.2992 160**23 22332	6.2992 160**23 22332	7.375 H239649-H239610	7.000 HM237545-HM237510	7.000 HM237545-HM237510	7.8740 200RM92 5240	7.4803 190RM92 5238	6.6929 170RM92 5234
80,000	Bore, in. AFBMA No. Ref No.	7.0866 180**23 22336	6.6929 170**23 22334	6.6929 170**32 23234	8.000 EE420801-421437	8.000 EE420801-421437	7.000 HM237545-HM237510	8.6614 220RM92 5244	8.6614 220RM92 5244	7.0866 180RM92 5236
90,000	Bore, in. AFBMA No. Ref No.	7.4803 190**23 22338	7.0866 180**23 22336	7.0866 180**23 22336	8.000 EE420801-421437	8.000 EE420801-421437	7.000 HM237545-HM237510	9.4488 240RM92 5248	8.6614 220RM92 5244	7.4803 190RM92 5238
100,000	Bore, in. AFBMA No. Ref No.	7.8740 200**23 22340	7.4803 190**23 22338	7.4803 190**23 22338	9.000 EE700091-700167	8.000 EE420801-421437	8.000 EE420801-421437	9.4488 240RM92 5248	8.6614 220RM92 5244	7.8740 200RM92 5240

For ** insert letters SC or SD or SLB for desired spherical bearing design.

Pittsburgh (22), Pa., Attention I. E. Madsen, standards engineer, for compilation and submission to overall AISE Crane Committee.

AISE SPECIFICATION NO. 6—

BEARING DETAILS

34. Bearings. A. Anti-friction bearings shall be spherical, tapered, straight or a combination thereof as specified on the information sheets.

B. Anti-friction bearings shall be selected on the basis of B-10 life of each size as to give a minimum life expectancy of 10 years (5000–40,000 hr) under the service conditions for which the crane is intended. Bearing selection in this specification is based on the total number of cycles which it is expected the bearing will undergo during the number of hours service the crane will be used in a 10-year period. Where other data is not available, the number of hours for the various motions can be estimated from Table 43-3-Crane Service Data. The required hours of service per year will be that given for the motion concerned (bridge, trolley or hoist) in this table if not otherwise specified.

C. Table 34-I Bearings for Bridge and Trolley Track Wheel Axles gives recommended bearing applications for track wheels. This table is based on AFBMA (Anti-Friction Bearing Manufacturers' Association) standards and nomenclature. It is not limited to any specific manufacturer's bearing. All bearings selected on the basis of Table 34-I must also meet the required life of 75 per cent of maximum box load based on the published catalog rating of the manufacturer of the bearing selected. Three types of bearings are listed: spherical, tapered and straight bearings. Reference numbers indicated refer to nomenclature commonly used at the present by mechanical designers. The bore is given in inches. Bearings in table are selected for 75 per cent of the maximum box load listed in the table on the assumption that this gives a practical average value for fatigue life purposes. If load on bearing is essentially constant, then box load values in table will be multiplied by 1.33 before selecting bearing. Bores were selected to limit axle stresses to 8000 psi at the maximum box load thus disregarding the 75 per cent load factor used in selection for bearing life. In some cases axle sizes establish bearing sizes. The spherical columns have three sets of letters listed to indicate the three types of spherical bearings which will be acceptable for each particular load and number of cycles.

D. With bridge track wheel bearings of anti-friction type, one bearing on each track wheel axle shall be of fixed double thrust type; the other bearing shall be arranged to allow for expansion or float of the axle.

E. Where sleeve bearings are applied to track wheel axles, the bearing pressure shall not exceed 750 psi of projected area except when aluminum bronze bearings are used. Then bearing pressures shall not exceed 1200 psi. Bearings are to be of such design as to exclude dirt, prevent leakage of oil or grease, eliminate the necessity for frequent oiling or replacement of oil, and meet with approval of purchaser.

F. Anti-friction bearings, where the load is not constant, for applications other than bridge and trolley track wheel axles shall be based on a load which is equal to 75 per cent of the maximum load which can be applied to the bearing, with the crane loaded in such a manner as to apply the worst load condition to that particular bearing. Bearing shall be selected so that it will meet the 75 per cent load with a B-10 life rating which will insure the number of cycles required on that bearing for 10 years total crane life. If the load is constant, life of bearing shall be selected on actual load.

G. Drawings showing size and type of bearings, details of application, mounting and method of application shall be submitted by the contractor to the bearing manufacturer for approval.

H. Anti-friction line shaft bearings shall have inner races, and preferably be of self-alining type. Method of securing inner races to shaft is to be approved by purchaser. A split anti-friction bearing may also be used.

I. Anti-friction bearings shall be fitted with grease or oil seals of a type approved by purchaser.

J. Gear housings for anti-friction bearings shall be split, or designed to permit easy removal of the shaft.

K. All bearing caps shall be accurately bored or machined in place with the housings. ▲

AISE Standards Currently Available

AISE Standard No. 1 — D-C MILL MOTOR STANDARDS..... $0.25 ea.

AISE Standard No. 3 — STANDARDS FOR MACHINED SURFACE FINISHES..... 0.25 ea.

AISE Standard No. 4 — SLING AND CRANE CHAIN STANDARDS. 0.25 ea.

AISE Standard No. 5 — STANDARDS FOR WIRING DIAGRAMS... 0.25 ea.

AISE Standard No. 6 — SPECIFICATIONS FOR ELECTRIC OVERHEAD TRAVELING CRANES FOR STEEL MILL SERVICE..... 1.00 ea.

AISE Standard No. 7 — SPECIFICATIONS FOR DESIGN OF LADLE HOOKS..... 0.25 ea.

AISE Standard No. 9 — STANDARDS FOR DESIGN OF HOT METAL LADLES..... 0.25 ea.

AISE Standard No. 11 — D-C MILL MOTOR BRAKE STANDARD... 0.25 ea.

AISE Standard No. 12 — PLAIN BEARING RECOMMENDED PRACTICE..... 1.00 ea.

Quantity prices may be obtained on request.

Minimum price for any order $1.00.

Report on Proposed A-C Crane Sections for AISE EOT Crane Specifications

by F. M. BLUM,
Chairman,
Subcommittee on A-C Cranes
and I. E. MADSEN
Research and Standards Engineer
AISE

WITH the increased interest by the steel industry in the use of a-c cranes which has resulted from advances in the development of a-c control equipment, and because of the operating economies and capital savings in new installations which may be attained in some cases, the AISE Crane Committee under the chairmanship of R. L. Livingston, chief electrical engineer of the United States Steel Corp., decided that the AISE Specifications for Electric Overhead Traveling Cranes for Steel Mill Service—AISE Standard No. 6, which is now being revised should include requirements for a-c cranes. A subcommittee was appointed to do this work under the chairmanship of F. M. Blum, general sales manager, Industrial Div., Harnischfeger Corp. with representation from other crane companies (manufacturers) and steel companies (users).

This draft was prepared, taking into account available control and motors. However, during the committee work, it became evident that an interchangeable a-c type mill motor might be desirable. Accordingly, the Board of Directors of the AISE reactivated its mill motor committee and assigned it the task of developing such a motor. M. B. Antrim, manager, engineering and construction, Lukens Steel Co., is chairman of this committee. Work is actively underway by this group consisting of motor manufacturers and steel plant electrical engineers. The a-c mill motor is not being engineered for crane applications exclusively but also for mill applications where the present AISE d-c mill motor is being used.

As is true of all specifications developed through cooperative committee work, the final results are necessarily a compromise of many divergent views. Several viewpoints on some of the issues (including one by the chairman) are included in the discussions following the draft specification.

This draft is tentative, and is *not being published for use*. It is the draft, however, being submitted by the a-c crane subcommittee to the whole crane committee for their consideration and adoption. Its publication here is to inform AISE members, and crane equipment users and manufacturers what is being considered. Comments and suggestions are invited for consideration by the crane committee when final adoption is scheduled. Such comments should be sent to AISE, 1010 Empire Building, Pittsburgh (22), Pa., Attention I. E. Madsen, standards engineer, for compilation. Approval and favorable comments are also solicited. With the wide usage of AISE crane specifications, it is felt that publication of this draft will best obtain the suggestions needed to ensure that the specifications best reflect the requirements of the steel industry.

It should be remembered that these are draft specifications only. There will undoubtedly be changes, final approval will also be dependent on what is in the final a-c mill motor standard.

As this draft was written, an attempt was made to parallel the style and content of the corresponding sections in the d-c standard. Perhaps this is not the most logical procedure.

Some of the areas with the greatest variation in viewpoints are the following:

1. Brakes. (Par 38). Note that several approaches are used on various applications. Also, bridge brake clause does not have a stopping distance requirement such as in the d-c crane specifications.

2. Bridge motor. (Par 43 E 2 b)

The 1.7 factor here has an important effect on the final rating. Values as low as 1.3 are used. Control manufacturers should check whether this is consistent with control offered.

3. Wiring. (Par 47). Present AISE wiring standard governs now. This is less restrictive than the National Electrical Code, but for heavy duty service may require larger sizes than current practice by some manufacturers.

4. Motors. Minimum breakdown torque of proposed a-c mill motor standard is 325 per cent instead of 275 per cent. Not enough design work has yet been done to develop which is most desirable.

Latest motor ratings and speeds differ from those in draft standard.

Should motor be designed for 150 or 200 per cent overspeed?

ELECTRICAL DETAILS

The following sections are applicable to a-c cranes. A-c cranes are defined as those cranes with all motions driven by a-c motors. If some motions are a-c and other d-c, the a-c motions will meet the requirements of the following paragraphs (paragraph numbers to come) and the d-c motions will meet the requirements of paragraphs (paragraph numbers to come). Combinations of a-c and d-c, such as adjustable voltage, packaged rectifier d-c drives and so forth, will comply with the applicable portions of either the a-c or d-c section.

38. Brakes. A. Hoist Brakes: Each hoist equipped with off-position electrical braking shall have a magnetic brake built to AISE standard dimensions and ratings and selected on the basis of 150 per cent full load hoisting torque. Hoists without off-position electrical braking shall have magnetic brakes selected on the basis of 200 per cent full load hoisting torque.

On all hoists handling hot metal or with a rating of 25 tons or greater, or if specified on the information sheets, the motion is to be equipped with a second magnetic brake. This brake shall duplicate the other brake and be mounted on the slip ring end of the rotor shaft. Each of these brakes is to be rated at least 100 per cent full load hoisting torque.

The main motor brake is to be mounted on the outboard end of the gear reducer's motor pinion shaft, the end of which shall have a tapered fit for the brake wheel of the same dimensions as that of the rotor shaft. All brakes are to be operated through a d-c magnet. The d-c coil shall provide quick response similar to a d-c series-wound coil. Direct current shall be provided by individual dry type rectifiers or control sources.

B. Trolley Brakes: Where specified, trolley motions shall be provided with an electric brake selected on the basis of 50 per cent torque of the trolley motor. This brake shall be adjustable so that its torque rating can be decreased by 50 per cent of the brake torque rating.

C. Bridge Brakes: 1. Unless otherwise specified, each bridge drive shall be equipped with hydraulic brake or brakes. The size of brake furnished shall be the responsibility of the contractor.

2. The stroke of the bridge brake foot pedal shall not be more than 8 in., and lever shall be so designed that it will not interfere with necessary movements of operator's legs or feet while operating the crane.

3. If normal braking is provided by electric plugging only, a d-c operated magnetic parking brake shall be provided for parking, or loss of power. Parking brake shall have same capacity as specified in Par. 38 C 1.

4. If specified on the information sheets, all cranes with bridge drive designed for more than 300-fpm bridge speed shall be provided with additional braking for the bridge motor which will provide automatic braking in both directions for deceleration upon power failure.

5. If specified, cranes shall be provided with electro-hydraulic brakes on the bridge drive, so arranged that brake will be set when the main disconnection switch on the foot-walk or in the cab is opened.

41. Conductors. A. If specified on information sheets, festooned cables may be used. In this event remainder of Paragraphs 41 and 42 is not applicable to motions supplied by cable.

B. Conductors shall be mounted outside of girders and above the deck of the foot-walk and shall be of the rigid type. Where low contact resistance is required for low current or voltage pilot devices, suitable combinations of conductor material and collector shall be used.

C. Where possible, conductors shall be of single length; otherwise, sections of conductors are to be spliced butt-welded together with contact surface at weld ground smooth. On cranes where conductors cannot be shipped assembled, sections of bars shall be welded or properly spliced. Welds should be ground smooth at erection, unless otherwise specified. The preference would be to splice nonferrous materials and weld ferrous materials.

D. The vertical clearance between conductor contact shoes and the adjacent conductor supports shall not be less than 1¼ in.

E. On cranes for which magnet cable reels are not specified, provision is to be made on conductor supports and collector staff for two additional bars and shoes that could be used for magnet control or other purposes. Common conductors are not to be used for power circuits.

F. The main conductors for the crane bridge travel will be furnished and erected by the purchaser. Location and size of these conductors will be furnished by the purchaser.

G. Supports for conductor bars shall be spaced not more than 6 ft for flat bars, and not more than 8 ft for shapes.

42. Collector Shoes. A. All collectors (two for each conductor) are to be furnished by the contractor, unless otherwise specified by purchaser. Means for easy access to these shoes for repairs shall be provided.

B. All collector shoes are to be spring loaded unless otherwise specified. Make and type shall be specified on information sheets.

43. Motors. A. Until AISE a-c motor standards are adopted, a-c motors used on cranes shall be wound-rotor type, totally enclosed, nonventilated, with anti-friction bearings and double taper shaft extensions. Minimum breakdown torque of the motor with rated voltage and frequency shall be at least 275 per cent. Motors are to be built to withstand an overspeed of 50 per cent and the windings are to be a minimum of Class B insulated, rated 60-min 75 C. Provision shall be made on the crane by means of lugs or similar construction to line up and hold motors in correct

position to eliminate the shear on the motor foot bolts.

B. The synchronous speed of motors will be as follows:

Up through 50 hp	1200 rpm
51 through 150 hp	900 rpm
Above 150 hp	720 rpm

C. Shaft extensions shall have a taper of 1¼ in. per foot. (Note: Future motor design standards should consider making shafts of AISE d-c mill motors and a-c motors interchangeable.)

D. Motor secondary data shall be in accordance with existing NEMA standards for crane motors. (MG1-7.203).

E. The size of the motor required shall be sufficient to meet the duty cycle requirements specifically. When duty cycle requirements are not known, the size of the motor shall be based upon the one-hour rating of the motors and calculated as follows:

1. Hoist Motor: The hoist motor shall be so selected that its one-hour rating will be not less than that given by the following formula:

$$HP = \frac{WV}{33{,}000E}$$

where:

W = weight of the rated load on the hook plus the weight of the block and cable in lb
V = specified hoisting speed in fpm
E = combined efficiency of gears and sheaves

The following tabulation gives some of these values for roller bearings for convenience. If sleeve bearings are used, see formula. (Note: The efficiency of the sheaves and so forth which follow are to be checked by the over-all crane committee and the A-C specification subcommittee.)

	Efficiency roller bearings	
No. Sheaves	*2-Reductions*	*3-Reductions*
1	0.89	0.84
2	0.88	0.83
3	0.88	0.83
4	0.87	0.82
5	0.86	0.82
6	0.85	0.81
7	0.84	0.80
8	0.83	0.79
9	0.82	0.78
10	0.81	0.77

The above tabulation is based on two or three pairs of gears, which covers most cases. However, if other combinations are used, the efficiency shall be computed by the following formulae:

$E = 0.93^n \times 0.98^m$ for sleeve bearings
$E = 0.95^n \times 0.99^m$ for roller bearings

where:

n = number of pairs of gears, and
m = total number of rotating sheaves between drum and equalizer passed over by the moving rope. (For double parts reeving only)

TABLE 43-I
Exponents for Hoist Motor Formula

Power	0.93	0.95	0.98	0.99
1	0.930	0.950	0.980	0.990
2	0.865	0.902	0.960	0.980
3	0.805	0.857	0.942	0.971
4	0.748	0.814	0.922	0.962
5	0.696	0.774	0.904	0.952
6	0.647	0.735	0.886	0.942
7	0.603	0.698	0.868	0.933
8	0.560	0.664	0.850	0.924
9	0.521	0.630	0.843	0.914
10	0.484	0.598	0.816	0.904

Efficiencies for various values of exponents are given in Table 43-I.

2. Bridge and Trolley Motor: (a) The force required to drive the bridge or trolley consists of that necessary to overcome rolling friction, and provide for acceleration. The rolling friction is proportional to the total weight of the crane, or trolley (whichever is applicable), and is assumed to be constant at all speeds. If not otherwise specified on the information sheets, an over-all friction factor of 15 lb per ton will be used for roller bearing cranes or trolleys and 24 lb per ton for sleeve bearing cranes or trolleys. Mechanical efficiencies are included in these factors.

(b) The minimum 1-hr rating of the bridge or trolley motors shall be at least that computed by the following formula:

$$HP = \frac{K \times 2000\ WV}{33{,}000\ (1.7)} \times \left(\frac{T}{2000} + \frac{a}{32EF}\right)$$

where:

K = service factor
W = weight of crane plus load in tons for bridge motor computations, and weight of trolley plus load for trolley motor computations
V = rated speed in fpm
T = rolling friction in lb per ton including efficiency of the drive
a = average acceleration in feet per second per second up to 90 per cent rated speed
E = mechanical efficiency of gearing = 0.95 per reduction
F = factors for acceleration of rotating parts = 0.90

Acceleration rate will be as specified on the information sheet. As a guide an average over-all acceleration of 0.38 feet per second per second would be considered slow, 0.75 feet per second per second would be average, and 1.1 feet per second per second would be fast. These correspond to results obtained for accelerations of 0.5, 1.0, and 1.5 feet per second per second while on resistor on d-c cranes. To meet service requirements, however, value of K in previous formula will be that required by duty cycle, if known, and if the duty cycle is not known, will be the value required for the various crane services as established by Tables 43-II and 43-III

44. Controls. A. Magnetic or static control shall be used on all motions of the crane.

B. Control shall be in accordance with the following:

1. Control shall conform to NEMA Industrial Control standards for Class V overhead traveling cranes, except as modified by these specifications.

2. The voltages in pushbuttons, master switches and similar remote control circuit devices shall not exceed 120-volt a-c, or 250-volt d-c.

3. Contactors for static elements shall be mounted on Monson slate or steel panels or other suitable switchboard materials, of ample thickness on suitable supports, with bottom of lowest devices not less than 6 in. from the floor.

4. All contactors, size IV and above by NEMA standard, shall be constructed with clapper type magnets operated from a d-c source. Contactors will be equipped with means of extinguishing and confining the arc.

5. Lowering shall be accomplished by an electrical braking system without the use of a mechanical load brake. For hook service, relatively flat speed control will be furnished capable of providing speeds down to 25 per cent rated speed or less when lowering full load and capable of providing speed down to 40 per cent or less of rated speed when hoisting an empty hook.

Hoisting will take place only when master is in hoist position. For all loads up to rated load, lowering will take place only when master is in lowering position. For bucket or magnet service, magnetic counter-torque control may be provided.

6. Control shall be so designed that it will not be possible to release hoist brake during a single phase condition.

7. Controls for all motions of the crane shall be equipped with voltage, frequency, definite time, or static regulator acceleration devices. Plugging protection shall be provided on all bridge and trolley control panels.

8. If specified on the information sheets, means of emergency braking shall be provided to prevent free falling loads under conditions of simultaneous power failure and electric brake failure.

9. If enclosures are required for the control panels, the type of enclosure shall be in accordance with the classifications as listed in the Industrial Control Section of NEMA standards, and shall be so specified on the information sheets.

10. Nonbreakable resistors shall be of NEMA classification numbers as specified on the information sheet. Resistors shall be based on load computation to give specified acceleration and not on motor size, which may be set by thermal requirements.

45. Hoist Limit Switch. A. Each hoist motor shall be equipped with a motor circuit limit stop connected directly in the motor and brake coil circuits to prevent overtravel in hoisting. The limit stop shall have a back-off circuit for lowering hook from the hoist master controller. The limit stop shall be located so as to be easily accessible for inspection and, if possible, so it will be operated by the hook block or load beam in such a manner that no sheave wheels are necessary. Limit switches must reset properly and must be designed to prevent grounds.

B. A weight, directly connected with the limit switch and suitable guides acting on the idler cables so that twisting cannot occur shall be used. Cable guides should preferably have replaceable maple or bakelite guide blocks to prevent wear on the cable.

C. If specified on the information sheet, an arrangement using a free swinging weighted beam, hinged on one end and having the other end attached to the limit switch operating cable, shall be used to operate the limit switch. The trip bar shall be so designed that the cables cannot jump out around the end of the trip bar, thus permitting the hook to raise outside the trip bar. The trip bar shall also be so designed that no movement of the hoist and trolley can enable the trip bar to be jammed against any part of the crane structure.

D. The actuating mechanism of the limit switch must be located so that it will trip the limit switch, under all conditions of hoist load and hoist speed, in sufficient time to prevent contact of upper and lower blocks.

E. If sheaves are used in connection with the hoist limit stop, the pitch diameter shall not be less than 18 times the rope diameter. Cables should be guided through a hole in both ends of the sheave guard. Sheave bearings shall be of anti-friction type. Design should eliminate dirt from bearings.

46. Disconnecting Switches. A. Each crane shall be provided with a main disconnecting switch of the fused or unfused enclosed type, as specified, with provisions made for locking in the open position with three safety locks, and of sufficient size to meet the National Board of Fire Underwriters' requirements. This switch is to be located on the foot-walk at a point as near as possible to the main collectors. Where switches of 400-amp capacity or greater are required, a three-pole circuit breaker or magnetic disconnect with fuses shall be used.

B. A second switch or circuit breaker or means for operating the main disconnecting switch on the foot-walk shall be provided in the cab, if specified on the information sheets.

C. The following fused safety switches or "no fuse" air circuit breakers, all mounted on a small panel in the cab, shall be provided: (1) One for crane lights. (2) One for electric heater and ventilating unit. (3) One for convenience outlet circuits. (4) One for signal lights. (5) One each for special devices, when applicable, such as sanders, motor operated buckets, turning devices, etc.

47. Wiring. A. Wiring will conform to AISE Standard No. 8-Crane and Mill Auxiliary Drive Motor Cable Size Wiring Standard.

B. If conduit is used it shall be rigidly attached to the crane to prevent vibration, and shall have suitable bushings at all terminals. When conduit is used, each motor shall be wired independently in separate conduits without common returns.

C. The following standard method of wiring should be used: 1. From main collector shoes, the wiring will extend to the three-pole safety switch or circuit breaker mounted on foot-walk.

2. When a second disconnect is used in the cab, wiring will extend to the main switch or circuit breaker in cab.

3. From this switch or circuit breaker, branch circuits will extend to control panels for hoist, bridge and trolley motions. A small panel mounting the switches for light, heater, convenience outlets, etc., and magnet circuit switch will be located ahead of disconnecting means on the foot-walk, unless otherwise specified.

D. If specified, three 120-volt convenience outlets, of type approved by the purchaser, for plug receptacles

are to be furnished on each crane; one on each walkway near middle of span and one in the cab.

48. Magnet Equipment. When specified on the information sheets that a magnet is to be used in conjunction with the crane, either a motor-generator set or a dry type rectifying unit of suitable capacity for rectifying alternating current to 230-volt direct current shall be used for magnet service. When rectifiers are used, magnet controller must be of the type specifically designed for use with the rectifier power supply.

A. On cranes where magnet cable reel, or space for mounting a reel is specified, it must be so located that magnet cable will not foul hoisting cable and, if possible, avoid the use of sheaves or guide rollers for the magnet cable.

B. If the cable reel is of the type driven by gears from hoist shafting, or from extension of the drum shaft, the surface speed of the reel shall be the same as the hook speed, and a loop shall be provided in magnet cable to allow for slack. If specified, this type of reel shall be provided with a clutch for disconnecting when magnet is not in use.

C. Weather protection shall be provided for magnet cable collector rings on cranes for outdoor service.

49. Lighting. A. All incandescent lighting shall be 120 volts. Crane cabs shall be provided with adequate lighting.

B. On the bridge structure of each crane, there shall be provided lighting fixtures, as specified on the information sheets. Lighting fixtures are to be mounted on shock absorbers, and so installed that they can be serviced from bridge foot-walks.

50. Signal Lights. A. Each crane is to be equipped with 120-volt signal lights; with number, location, color and connections as specified on the information sheets.

Discussion

PRESENTED BY

F. M. BLUM, General Sales Manager, Industrial Div., Harnischfeger Corp., Milwaukee, Wisc.

S. RIFKIN, Senior Application Engineer, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

F. M. Blum: A change in Paragraph 47—Wiring—is recommended because the present AISE Specification No. 6 requires 60-min rated motors, but we cannot select wire size and conduit on this rating. We must refer to AISE Standard No. 8, Table 1, to determine if the crane is average intermittent duty or heavy intermittent duty. If average duty, then the wire size and conduit correspond to the 60-min motor rating. If heavy duty, then the wire size and conduit correspond to the 30-min motor rating. It is our opinion that the wire size should agree with the motor rating which already has a service factor in it without resorting to a shorter time rating and increasing the wire size still further.

In respect to Paragraph 43—Motors (Sub-paragraph 2—Bridge and Trolley Motors, Item b.), this formula, our engineers feel, is the point of greatest contention. We wonder whether all controls will develop an average of 170 per cent torque between 0 and 90 per cent rated speed. Several companies stated their controls did in the open committee meeting. We have attempted to locate performance curves from competitive control manufacturers. Those we have do not indicate that these curves will develop an average of 170 per cent torque, but the actual torque cannot be established since the points of contactor closing are not indicated.

If the 170 per cent figure is finally adopted, our company can also meet this requirement with certain changes in the setting of its accelerating relays and resistor calculations. We would suggest, however, that since this is such a controversial issue that you poll the rest of the control industry for their comment, or, you might wish to do it through publication of the interim report.

It is also our opinion that the K_a factor should not increase the motor horsepower, but it should increase the frame size in order to dissipate the motor rating.

Paragraph 38—Brakes—These paragraphs read as though these were made in committee. The brakes on the hoist motor, trolley motors and bridge motor are all selected in a different manner. Brake applications have two considerations: one, to provide the torque to meet a specified deceleration, and two, to be able to absorb the energy from the number of stops specified. To meet the first requirement a formula for brake horsepower similar to motor horsepower can be used. The matter of adapting brakes to cranes is identical whether it is a d-c crane or an a-c crane and maybe this paragraph should be reviewed by the AISE No. 6 Committee as a whole.

S. Rifkin: When using the subject proposed standards in connection with certain orders, we have found the bridge and trolley motor formula under Section 43 E2b much too cumbersome for frequent usage. We would recommend that the standards include a set of curves to help simplify the calculations. The chart proposed by H. A. Schaill would be quite helpful, especially if a few additional curves were added for other rates of acceleration. In any event, we believe it would be advisable to have similar procedures for a-c and d-c cranes; therefore, if Figure 43-1 is to be retained in the revised d-c standards, the attached set of curves (Figure 1) may be useful in the a-c standards, with HP = K_aWV times service factor.

In addition, we believe that more definite guidance should be given in the a-c standards with regard to performance equivalent to that obtained on d-c cranes, and would like to offer the following comments for consideration. At the end of page CS-38 as of May 1, 1949, AISE Standard No. 6, the assumption is made that the resistor will be cut out at approximately $\frac{2}{3}$ of the top speed. Since the proposed a-c formula assumes that the average acceleration applies up to 90 per cent of rated speed, equivalent performance for short distances would be obtained by using the same rate of acceleration and by specifying the a-c crane speed to be 0.67/0.9 or 0.75 per cent of the rated speed that would be used for a d-c crane. The CS-38 reference also states that the overall acceleration rate on a d-c crane will be 3/4 the acceleration on the resistor. In comparison, using the assumed average motor torque of 170 per cent during acceleration up to 90 per cent

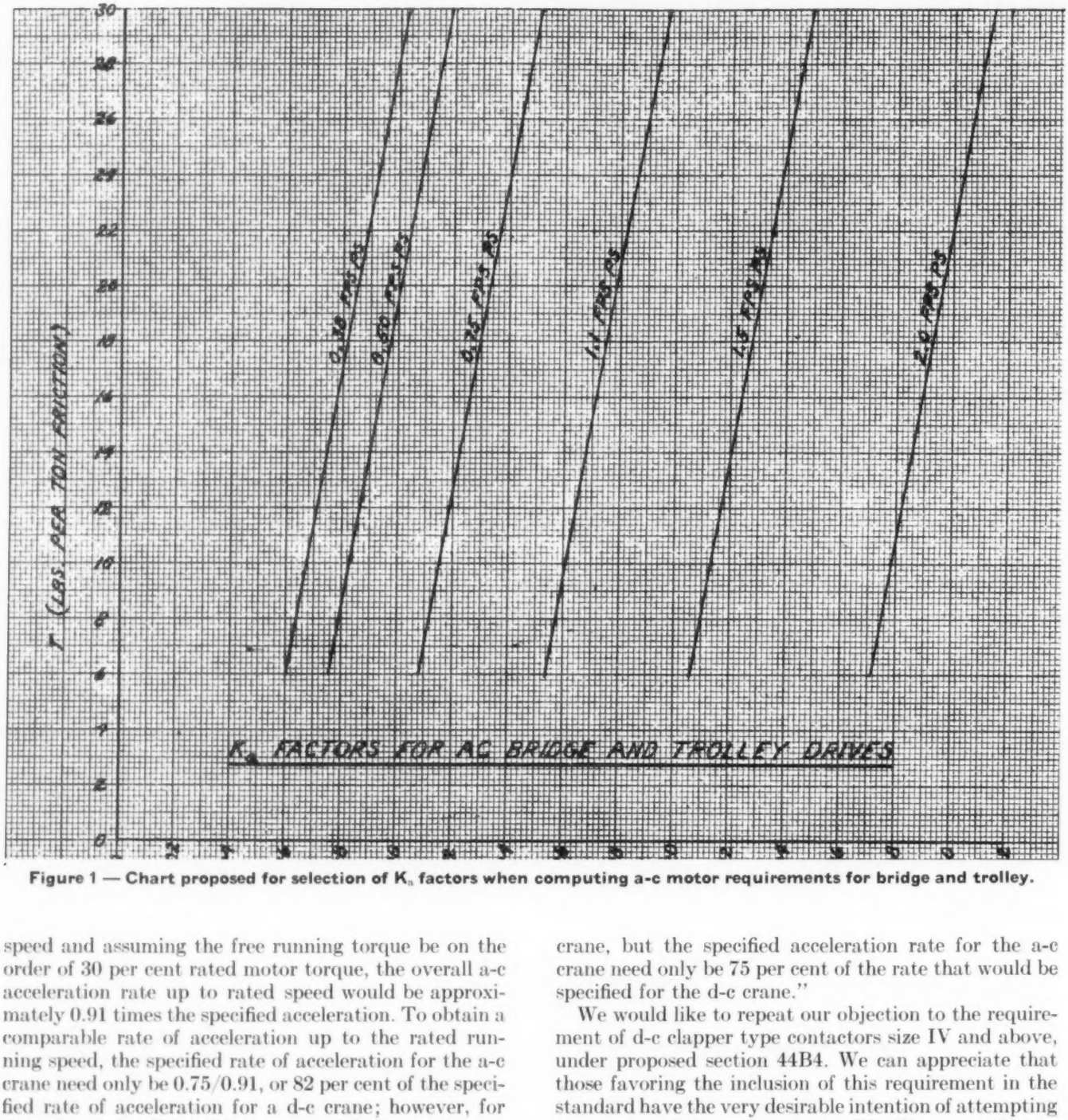


Figure 1 — Chart proposed for selection of K_a factors when computing a-c motor requirements for bridge and trolley.

speed and assuming the free running torque be on the order of 30 per cent rated motor torque, the overall a-c acceleration rate up to rated speed would be approximately 0.91 times the specified acceleration. To obtain a comparable rate of acceleration up to the rated running speed, the specified rate of acceleration for the a-c crane need only be 0.75/0.91, or 82 per cent of the specified rate of acceleration for a d-c crane; however, for the sake of simplicity, 75 per cent might be used.

Of course, many assumptions have been made in both the a-c and the d-c procedures; however, we would like to suggest considering the possible use of the following in paragraph 43 E2b of the proposed a-c standard:

"If the primary usage of the crane under consideration involves bridge and/or trolley travel distances so short that a d-c motor would not have an opportunity to accelerate above 60 min rated speed, a comparable a-c crane motion could be rated at 75 per cent of the speed that would have been specified for the d-c crane, and the same specified rate of acceleration would apply. If the primary usage of the bridge and/or trolley motions involves relatively long distances, during which a d-c motor might approach free-running speed, the a-c crane should have the same rated speed as the d-c crane, but the specified acceleration rate for the a-c crane need only be 75 per cent of the rate that would be specified for the d-c crane."

We would like to repeat our objection to the requirement of d-c clapper type contactors size IV and above, under proposed section 44B4. We can appreciate that those favoring the inclusion of this requirement in the standard have the very desirable intention of attempting to assure satisfactory contactor life. However, this requirement tends to discourage development of better a-c devices. It seems obvious that it would be advantageous to all parties concerned to eliminate the d-c source from the control, if a satisfactory life can be obtained from an a-c solenoid-operated contactor. (This is especially desirable when contactors are to be subjected to relatively moderate duty.) Manufacturers attempting to supply devices that do not provide acceptable life will soon be excluded from quoting on new invitations. We would suggest that the first sentence of proposed paragraph 44B4 be changed to the following:

"When necessary to obtain satisfactory device life, contactors and relays may be constructed with clapper type magnets operated from a d-c source of adequate capacity." ▲

Motor Applications for Heavy Duty A-C Crane Service

by H. O. POLAND, Chief Engineer,
Motor and Generator Div., Harnischfeger Corp., Milwaukee, Wisc.

A-C electric motors are classified into two broad groups as related to the purpose for which they are to be used. First, of course, is the so-called "general purpose" motor, so termed because its application may consist of any of several drives which are not exacting in requirements as to torques or thermal capacity. This permits the use of a stock, or "off-the-shelf," motor which has design characteristics suited to many average applications, thus permitting high production levels and stocking for immediate sale. The second broad classification is the "specific purpose" motor which has all of its characteristics determined by the requirements of a specific application which differs from the average and therefore involves lower production and sales volume. In this latter category are motors that are associated with repetitive cycling wherein a malfunction from any reason can be very costly from the standpoint of production shutdown, or personal safety, or both.

An outstanding illustration of such a specific purpose motor is one that is used with an overhead traveling crane used for constant duty on a repetitive cycle such as encountered in any productive process; examples being foundry cranes, magnet and grab bucket cranes, and similar types requiring many operations per hour as contrasted with those involving only an occasional operation or infrequent cycles. The first-mentioned types may be designated as Class 3 or Class 4 cranes, and more broadly as heavy duty cranes. If they are powered by alternating current the motors are of the wound-rotor type to facilitate the control of speed and torque as required by their duty. Because the application is such that the loading is not constant, and repetitive accelerations, stops, and reversals with reliability are a necessary function, the motors *must* be designed and applied for the specific service they are to perform.

Proper selection of the correct a-c motors must take into account the following three considerations in construction and design, described in order of their difficulty of evaluation:

First, construction features are relatively easy to specify for the application. Because ambient conditions usually involve exposure to weather, or dirty or corrosive atmospheres, totally enclosed motors are generally used. They may or may not be fan cooled, depending upon the nature of the duty cycle. Because of reversing service and repetitive speed changes and stops, as well as overspeed possibilities, the rotor coils must be particularly well secured against movement by adequate wedging in the slots and banding support of the coil ends. Since the decelerations, stops, and braking against overhauling loads are frequently accomplished by reversing the emf field in the air gap, commonly known as countertorque or plugging, the voltages induced in the rotor winding may become relatively high. This calls for an adequate dielectric level in the insulation as well as thorough durability for the constantly varying conditions encountered.

. . . . paper was presented at AIEE Materials Handling Conference, Philadelphia, Pa., April 13, 1960 . . . . with current work by AISE on standardization of a-c mill motors and a-c crane standards, this paper is particularly pertinent . . . .

Second, speed-torque characteristics required in the motor may be determined with little trouble if the exact nature of the loading and required duty cycle are known. These factors can be relatively simply predetermined in conjunction with the control system, and the electrical and magnetic design established as required.

Third, assuming that the motor is correctly designed and applied in its construction and speed-torque features, it is necessary that it possess adequate thermal capacity for the intended duty cycle. Any motor operating on a repeating cycle will stabilize at a temperature rise such that the heat rejected will equal the heat generated. If the motor does not have sufficient thermal capacity this temperature will be high enough to greatly reduce the life of the insulation and promote burnouts, as well as troubles with mechanical parts. Herein lies the most involved factor in proper motor selection for a duty cycle, inasmuch as such motors have standardized ratings on a short time basis because of the noncontinuous type of loading. However, in actual usage the motors are *not* loaded just as their short time rating states. That is, they are not fully loaded for a specified time and then allowed to cool before another loading period starts. Therefore it becomes necessary to select a short time rating that represents adequate thermal capacity for the required duty cycle.

It is known that a motor starting from rest must absorb a certain amount of heat energy in its material before attaining a stabilized temperature. This occurs during the first portion of the loaded period, with alternating heating and cooling if the load varies. However if the cycling continually repeats, a condition will be attained such that the motor has absorbed sufficient heat to raise its temperature for enough above the surrounding atmosphere (ambient) so that its heat rejection will equal the heat developed by the repeating load conditions. The important factor is that the operating temperature of the motor, and therefore its reliability and life, depends upon its ability to dissipate the heat losses of the duty cycle. This ability obviously depends upon the magnitude of the heat dissipation surface and must not be confused with other characteristics, such as derated designs, which might adversely affect other components in the over-all motor and control system. Tests have shown typical heat dissipation factors as follows in watt-seconds per sq in. per degree

	Totally-enclosed non-ventilated (TENV)	*Totally-enclosed fan-cooled (TEFC)*
Running at full speed	0.0085	0.015
Accelerating or decelerating, average	0.0075	0.012
At standstill	0.006	0.006

Correct selection for heat rejection capacity will therefore involve evaluation of the heat generated in cycling and comparing this with the capability of the motor for rejecting this heat at rated temperature or less. An example will illustrate this:

A crane bridge is to be operated on a cycle, as shown in Table I, requiring the speed-torque characteristics of a 100-hp, 900-rpm motor. A TENV motor rated 30-min 75-C rise is to be checked on the basis of full load constant losses of 3300 watts, stator variable losses 1300 watts, and rotor variable losses 1100 watts. It will be assumed that the loss expended in overcoming friction during acceleration will be recovered during deceleration through the assistance by friction.

The temperature rise required for dissipating the heat loss is given by

$$\theta \text{ (in degrees C)} = \frac{\text{Ed}}{\text{A}\Sigma(\text{Kt})}$$

where:

Ed = Watt-sec dissipated
A = Sq in. effective dissipating surface
K = Dissipation constant in watts per sq in. per degree C of gradient
t = Time in sec for each different part of the cycle

The motor selected has 3520 sq in. effective dissipating surface. Therefore:

$$\theta = \frac{130{,}330}{3520(11 \times 0.0075 + 15 \times 0.0085 + 10 \times 0.006)}$$

$$\theta = \frac{130{,}330}{3520 \times 0.27} = 137 \text{ C}$$

The temperature being 137 C, the motor chosen is too small for this duty cycle, and to limit the rise to rated 75 C the effective surface required would be:

$$\frac{137}{75} \times 3520 \text{ or } 6420 \text{ sq in. TENV}$$

If the length of run were reduced so as to require only two seconds at full speed the energy loss per cycle would be 84,960 watt-seconds, giving a temperature rise of

$$\frac{84{,}960}{3520\ (11 \times 0.0075 + 2 \times 0.0085 + 10 \times 0.006)} = 151.5 \text{ C}$$

The effect of shorter cycles with more frequent starts and stops can thus be seen as an appreciable factor, pointing out the importance of the *type* of cycle under consideration.

An expression can be developed, as shown in the appendix to this paper, for relating the short-time rating (STR) to a known duty cycle where such cycle has been evaluated on the basis of required heat dissipation surface. Thus:

$$\text{STR (min)} \geqq \frac{3.54}{(\text{LR}/\text{A}\theta) - 0.036}$$

where

L = Full load loss in watts
R = 4 for TEFC motors or 7.05 for TENV motors
A = effective dissipation surface in sq in.

For the 36-sec bridge drive cycle the STR rating, TENV, would then be:

$$\geqq \frac{3.54}{(6900 \times 7.05)/(6420 \times 75) - 0.036} \text{ or } 54.5 \text{ min}$$

Calculation of a suitable TEFC motor would show 67.8 min STR. For the short-run cycle the STR

TABLE I

	Time, sec	Per unit rotor current	Constant loss, watts	Variable loss, watts Stator	Rotor	Total loss, watts	Watt-sec
Acceleration	4	1.30	3300	745	1860	5905	23620
Running	15	0.35	3300	55	135	3490	52350
Deceleration	7	1.05	3300				54360
Standstill	10						
	36					Watt-sec per cycle =	130330

Stator losses are proportioned to rotor losses in ratio to their respective resistances as referred to the stator.
The variable energy loss from one plug stop is taken as equal to three times that of one start.

values for TENV and TEFC would be 64 and 98 min respectively.

The STR rating selected should therefore be a standard value which equals or exceeds the calculated value.

It is noted that the TEFC motor for the same duty cycle has less dissipating surface but longer STR rating than the TENV motor. This is because of the higher dissipation at rated speed. In fact, the shorter the full speed running part of the cycle in relation to the rest of the cycle, the longer will be the STR of a TEFC motor as compared with a TENV motor on the same cycle. This is an obvious conclusion from the fact that the higher dissipation factor 0.015, as compared to 0.0085, is in effect a relatively shorter time. From the relationship given, neglecting differences in efficiency, the short-time ratings of both types of motor are equal when the evaluated duty cycle shows the required dissipation surface of the TEFC motor as 56.7 per cent of that of the TENV motor, since:

$$\frac{LR}{A\theta} = \frac{4L}{0.567A\theta} = \frac{7.05L}{A\theta}$$

The numerical factors cited may vary slightly with details of manufacture. However, with a consistent method of analysis it is clearly evident that the selection of an a-c motor for heavy duty crane service must take into account not only physical details but also, and even more importantly, correlation of suitable speed-torque characteristics with fully adequate thermal capacity, or short-time rating as determined by the nature of the duty cycle. Briefly, the motor must be "tailor designed" for the specific conditions of operation if satisfactory and reliable performance is to be obtained. Derating of standard motors to meet a duty cycle does not suffice and may introduce troublesome conditions in the entire application.

APPENDIX

In establishing any motor rating in reference to time under load a certain amount of heat energy is developed due to motor losses. Some of this energy is absorbed by material in the motor, thus raising its temperature above that of the surrounding atmosphere, whereupon further energy is dissipated into the atmosphere and carried away by radiation and convection.

The amount of energy absorbed is dependent upon the specific heat of the material, the quantity of material, and the temperature to which it rises, or:

$$\text{Watt-sec} = 212 \times W(\text{lb}) \times \theta^\circ \quad \ldots\ldots (1)$$

where 212 watt-sec per lb per degree C (specific heat) applies to the average distribution of absorbent material in an a-c crane motor.

The amount of energy dissipated is dependent upon the dissipation factor, the area effective in dissipation, and the average temperature gradient, as well as the time involved, or:

$$\text{Watt-sec} = (K)\,(A)\,(\theta')\,(t) \quad \ldots\ldots (2)$$

From the exponential heating curve it can be found that the average gradient is 60 per cent of the final temperature rise θ. Therefore, the heat energy developed during the short-time test is distributed as:

$$212\ W\ \theta\ (\text{absorbed}) + 0.6KA\theta t\ (\text{dissipated}) \quad \ldots (3)$$

For TEFC crane motors the ratio R of effective dissipation surface in sq in. to effective heat absorption weight in pounds averages 4. The dissipation surface for a TENV motor rejecting the same heat losses must increase to compensate for the reduced dissipation factor or as $0.015/0.0085 = 1.765$. Thus the factor R for TENV motors becomes $1.765 \times 4 = 7.05$.

Using the ratio R, the distribution of heat energy in a short-time test results in the following expressions:

$$\text{Watt-sec} = Lt = 212 \times W \times \theta + 0.6\,(A)\,(\theta)\,(t)\,(K) \quad \ldots (4)$$

$$W = \frac{A}{R}$$

$$K \times R = 0.015 \times 4 = 0.0085 \times 7.05 = 0.06$$

$$t(L - 0.6A\theta K) = (212)\,(W)\,(\theta) = 212\,\theta\,\frac{A}{R} \quad \ldots (5)$$

$$t = \frac{212\,A\theta}{LR - 0.6RKA\theta} \quad \ldots\ldots (6)$$

whence:

$$t = \frac{212}{(LR/A\theta) - 0.036}\ \text{sec} \quad \ldots\ldots (7)$$

where $K = 0.06/R$
or in minutes,

$$t = \frac{354}{(LR/A\theta) - 0.036} \quad \ldots\ldots (8)$$

With full load loss, L, known (and also R and θ) it is therefore possible to calculate with reasonable accuracy the proper short-time rating in relation to the dissipation surface A as determined from evaluation of the losses of the duty cycle. ▲

Selection of A-C Hoist Motors on Continuous Duty Cranes

by A. NITSCH, General Electric Co., Schenectady, N. Y.

A CONTINUOUS duty crane is one which is designed to do a specific job of moving certain quantities of material in a prescribed time. NEMA defines a continuous duty crane as a Class IV application which includes cranes for handling bulk materials, scrap, logs, etc. Therefore, attention is focused on the hoist drives of bucket, magnet and grapple cranes. Application of continuous duty cranes are found in many basic industries such as cement, chemical, lumber, transportation, glass and steel.

Theoretically, the major difference between the continuous duty and the general industrial crane is that the work to be done by the continuous duty crane can usually be more precisely described. This is especially true with regard to the loads to be handled and the frequency of operation to obtain the material handling capacity in tons per hour or tons per day required.

The hoist drives associated with continuous duty cranes can be of the single motor variety, as in the case of magnet and some types of grapple cranes, or of the two motor variety associated with hold and close line bucket drives or two line grapple drives. Although designated as a continuous handling crane, the duty on each motion of the crane will still be of an intermittent nature. The per cent time that any one motion will be running during the operating cycle involved with moving the load from one place to another will be dependent on the following: (1) physical dimensional requirements such as hoisting, bridging and trolleying distances, (2) obstructions that may limit the simultaneous overlap operation of motions, and (3) the time involved in securing the load and removing the load from the crane. Since the material to be moved is handled usually only in one direction, the hoist drive is operating half the time without the load material, but with the appurtenances used to handle the load material, namely, the magnet, bucket, grapple, etc.

. . . . paper was presented at AIEE Materials Handling Conference, Philadelphia, Pa., April 13, 1960 . . . . with current work by AISE on standardization of a-c mill motors and a-c crane standards, this paper is particularly pertinent . . . .

APPLICATION CONSIDERATIONS

For a particular continuous duty crane, the selection of an a-c hoist motor will involve the following application considerations:

1. Power supply
   - (a) Voltage.
   - (b) Frequency.
   - (c) Limitations on capacity.
2. Mechanical considerations
   - (a) Motor mounting position.
   - (b) Connection to load (coupled to gearing or pinion on motor shaft).
   - (c) Brake requirements.
   - (d) Load inertia.
3. Environment
   - (a) Dust (magnetic or nonmagnetic).
   - (b) Moisture.
   - (c) Ambient temperature.
   - (d) Altitude.
   - (e) Corrosive chemicals.

4. Specifications
   (a) Industry specifications (AISE, NEMA, etc.)
   (b) Customer specifications (including government agency specs.)
   (c) Other special requirements (AIEE No. 45, ABS, etc.)
5. Motor characteristics
   (a) Speed.
   (b) Torque.
   (c) Enclosure.
   (d) Thermal ability.

Interrelation exists between the motor characteristics and the other application requirements. For instance, environment or specifications may dictate motor enclosure. In addition, speed and maximum breakdown torque may be prescribed in special customer or industry specifications. However, in the general case of selecting the hoist motor of a continuous duty crane, the motor *torque* and *thermal ability* are paramount and all other application considerations should be evaluated in relation to their affect on the torque or thermal ability of the hoist motor selected.

HORSEPOWER AND TORQUE CONSIDERATIONS

All hoist motors must have sufficient torque capabilities to accelerate and hoist rated load in a reasonable time as well as sufficient torque to handle infrequent overloads. Selection of the hoist motor horsepower and gear ratio can be made on the basis of the following equations for single motor drives.

$$Hp = \frac{W \times V}{33{,}000 \times E} \quad \ldots\ldots\ldots\ldots (1)$$

$$GR = \frac{N}{R} \times \frac{D}{12} \times \frac{1}{V} \quad \ldots\ldots\ldots\ldots (2)$$

where:

Hp = horsepower to lift rated load.
W = rated load in lb plus any load handling appurtenances associated with the drive.
V = speed of load in fpm.
E = mechanical efficiency in per unit.
GR = gear ratio.
D = drum diameter in inches.
N = motor rpm.
R = rope reductions.

For two motor bucket or grapple drives, hold and close line type, equations 1 and 2 should be applied on the basis of the load to which each motor is subjected during hoisting. Since, in the majority of cases, approximately equal load division during hoisting is desired, motors of equal sizes are usually selected for two-motor bucket or grapple drives.

If the hoist motor is selected so that the calculated horsepower is equal to or less than the motor rated horsepower, sufficient torque will be available to meet the normal and reasonable overload requirements of the drive. Therefore, since the hoist motor selected will meet the torque requirements, the next step is to check whether the motor selected will meet the thermal requirements.

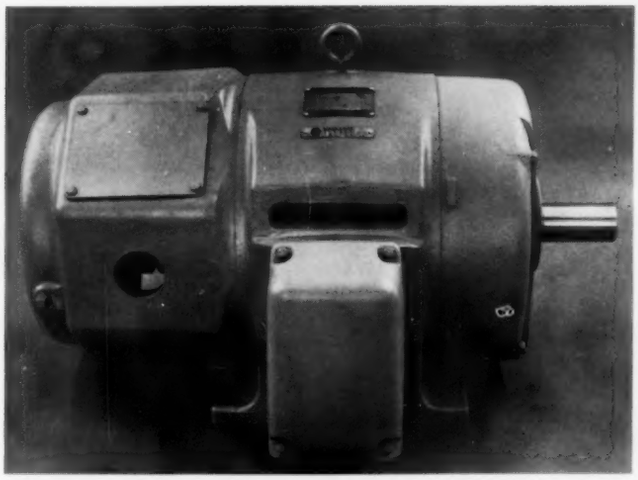


Figure 1 — Air flow is an important factor in rating dripproof wound-rotor crane motor.

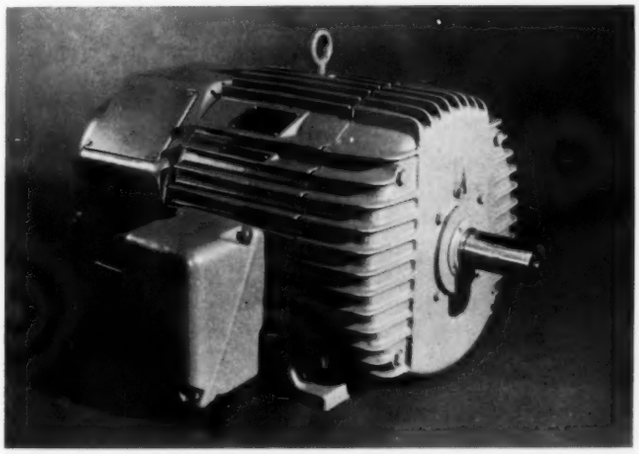


Figure 2 — Totally enclosed nonventilated wound-rotor crane motor must dissipate losses by frame radiation alone.

THERMAL CONSIDERATIONS

The ultimate steady-state temperature that a motor will attain will depend on the ability of the motor to dissipate the losses. Motor losses can be divided into constant losses (such as core losses) and varying losses. The varying losses include load losses plus stator and rotor copper losses, which are proportional to the square of primary and secondary currents, respectively. The losses for motors of equal horsepower and torque rating will depend primarily on the motor design. The dissipating ability, however, will depend on whether the motor enclosure is of the dripproof, totally enclosed nonventilated, totally enclosed fan-cooled, or separately ventilated construction.

Since hoist motor load cycles are characteristically of an intermittent nature on continuous duty cranes, short time rated motors with either dripproof construction, Figure 1 or totally enclosed nonventilated construction, Figure 2 are usually suitable.

In order to verify the thermal ability of short time rated dripproof motors without the need for motor design data, empirical factors were established by experience for a particular line of motors. For a short time, 60-min, rated dripproof wound-rotor motor a factor of 0.8 is used to relate the duty cycle equivalent rms rating to the short time rating. For example, a

TABLE I
Typical Rms Torque Calculation

Operation	Time (sec)	Torque (pu)	Equivalent time (sec)	Torque² time, (lb-ft)² sec	Distance (ft)
Accelerate hoist	2.0	1.64	1.33	5.39	2.00
Run hoist	18.5	0.98	18.50	17.80	37.00
Decelerate hoist	1.0	...	0.67	...	1.00
Accelerate lower	1.5	0.645	1.00	0.62	1.55
Run lower	17.1	0.264 (0.4)	17.10	2.74	35.35
Decelerate lower	3.0	0.720	2.00	1.56	3.10
Rest	9.0		3.00		
Total	52.1		43.60	28.11	

Equiv. rms T = $\sqrt{28.1/43.6}$ = 0.8 pu

Allowable continuous torque for dripproof 1-hr rated crane type wound-rotor motor is 0.8 pu. Motor will meet the above cycle repeated continuously without exceeding rated temperature rise.

100-hp, 60-min dripproof machine is assumed adequate for an equivalent rms cycle of 80 hp. For a 30-min rated motor, the factor is 0.7. Of course, these factors may not apply to all makes of wound-rotor motors. Their use allows the duty cycle applied to dripproof machines to be evaluated by an rms torque calculation.

When calculating the rms torque for a dripproof machine, however, an equivalent time other than the cycle time should be used. A dripproof motor running at rated speed can be considered to have 1 per unit dissipating ability by both fan action and frame radiation. During acceleration and deceleration when the average speed is one half the running speed, the dissipating ability will be decreased because of reduced air flow. At rest, the dissipating ability will be decreased further since no fan action is present. Empirical factors derived from experience which can be used to relate the motor dissipating ability and speed for crane type wound rotor motors are as follows:

At rated speed or above.....1.0 pu
At 50 per cent speed.....0.66 pu
At rest.....0.33 pu

The use of these factors on the time for each operating period of an rms duty cycle calculation will establish an equivalent time which will relate the intermittent cycle characteristics to the motor dissipating ability.

TABLE II
Typical Watts Loss Calculation

Operation	Time (sec)	Torque (pu)	Heat generated (watt-sec)	Distance (ft)
Accelerate hoist	3.5	1.64	45,000	3.50
Run hoist	17.5	0.98	108,000	35.00
Decelerate hoist	1.5	...	...	1.50
Accelerate lower	2.6	0.645	10,600	2.74
Run lower	16.2	0.264	43,400	33.53
Decelerate lower	3.6	1.00	16,400	3.75
Total run time	44.9			
Required rest time	36.1			
Cycle time	81.0		223,400	

Motor design data: Constant loss.....2400 watts
Variable loss.....3890 watts
Average frame dissipation.....2750 watts continuous for 55 C rise
Required cycle time = 223,400/2750 = 81.0 sec

Therefore, approximately 36 sec rest time is required for totally enclosed nonventilated 1-hr motor to meet duty repeated continuously without exceeding the rated temperature rise.

A totally enclosed, nonventilated motor must dissipate all of the losses by frame radiation alone. The internal fan action, while improving the internal heat flow, has little affect on the dissipating ability of the frame. The totally enclosed nonventilated short time rated motor, in most cases, cannot be applied on an equivalent rms basis. In fact a good many totally enclosed nonventilated machines will overheat if run at no load continuously. Therefore, the thermal verification of the selected totally enclosed nonventilated machine must be based on design data, and the watts loss method provides the most accurate results. This method compares the heat generated in the motor with the heat dissipating ability of the frame, and is best done by the motor manufacturer.

RMS TORQUE METHOD

Consider a hoist load cycle as shown in Table I. This cycle might be typical for a magnet crane and would be repeated continuously. Note that the duty cycle is evaluated by calculating the time, torque and distance for the acceleration, running and deceleration portions of the hoist-and-lower cycle. These calculations are based on the load torque and the total wk^2 of the drive system referred to the motor shaft, which includes the motor, brake, drum, gearing and load. When the calculated motor torque is below 0.4 of rated motor torque, the 0.4 figure is used to reflect the excitation losses of the wound-rotor motor. The calculations apply to drive systems where it can be assumed that the motor losses are proportional to the square of the torque. If this relation does not hold, other factors to relate the motor heating to torque must be included in the calculations. In the typical example, the dripproof motor would meet a 53-sec cycle continuously without exceeding rated temperature rise. The rest time in the cycle would be provided by the operating requirements of the bridge and trolley as well as the time it takes to secure and discharge the load.

For the application of a continuous rated motor, the same procedure would apply except that the rms torque could be equal or less than the motor rated torque without using the 0.8 empirical factor. The application of a separately ventilated motor can be evaluated by using the actual cycle time instead of the equivalent time since the heat dissipating ability would not be dependent on motor speed.

WATTS LOSS METHOD

Table II is indicative of a totally enclosed, nonventilated motor of equal horsepower, torque and time rating applied to the same steady state load conditions as the dripproof motor of Table I. The totally enclosed nonventilated motor used in the example required a larger frame size than the dripproof motor. The longer acceleration and deceleration periods reflect the difference in rotor inertia between the dripproof and totally enclosed nonventilated motors. This calculation assumes motor losses are proportional to the square of the torque when in actuality, the losses are proportional to the primary and secondary currents squared. If the drive system does not provide torque-ampere relationships indicative of motor heating, additional factors relating the torque and the current must be used.

The minimum cycle time that the totally enclosed nonventilated motor can meet without overheating is approximately 81 sec. If the operating requirements of the bridge and trolley as well as the time required to secure and discharge the load will provide the 36-sec rest time for the hoist, the motor selected will be adequate.

The frame dissipating ability of a totally enclosed nonventilated motor depends on the surface area of the frame and the ultimate temperature of the frame with respect to the ambient. Therefore, the use of Class B insulation with an allowable 75 C temperature rise above a 40 C ambient is beneficial in that frame radiating ability is improved. The use of cooling fins on motor frames increases the surface area and therefore, the radiating ability. Since there are many factors affecting the application of totally enclosed, nonventilated motor capabilities, no empirical factors have been established.

The application of a totally enclosed fan-cooled hoist motor can be verified with the watts loss method by factoring the effects of the fan during full speed, half speed, and rest on the dissipating ability of the motor.

PRACTICAL CONSIDERATIONS

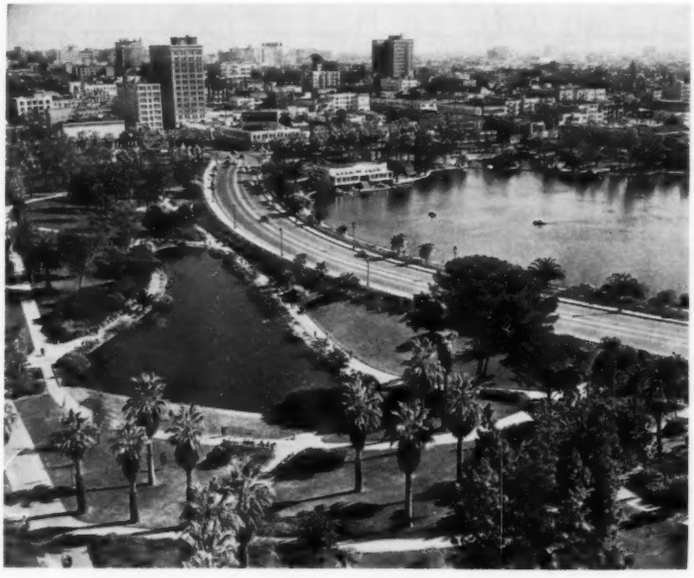
The theoretical duty cycles for hoist motors on continuous duty cranes must reflect the true operating conditions. Motors cannot be selected on an historical basis for identical cranes used on different continuous duty applications without taking a risk. Conditions may be encountered which may adversely affect motor heating, for instance:

1. Increased overlapping of hoist with bridge and trolley motions resulting in faster cycles.
2. Use of bucket with faster opening and closing characteristics resulting in faster cycles.
3. Use of crane for prolonged operations not reflected in the theoretical cycle.
4. Cranes applied in areas with different ambient conditions.

SUMMARY

The selection of hoist motors for continuous duty crane applications must be made from both a torque and thermal standpoint. The torque requirements can be evaluated by standard equations, and the thermal ability verified by either an rms torque or a watt loss calculation, depending on the motor enclosure to be used.

If environmental conditions allow the use of a dripproof motor on the hoist motions of continuous duty cranes, increased handling capacity can usually be obtained because of the shorter permissible cycles. ▲



1961
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MEETING

February 27, 28, March 1

Statler Hilton Hotel, Los Angeles, Calif.

Make Your Reservations Early

Controlling Oxygen

TO remain competitive today in the steel industry requires that production be maintained at a high level on existing equipment. Our high standard of living, the ever-increasing population, and the national defense program reflect a demand to outproduce any other age in history. To meet this challenge of changing times new methods and practices must be introduced and evaluated to prove their economic justification. This paper shall deal with application of these methods to a blast furnace.

There are many factors that contribute to the efficient operation of a blast furnace. A considerable amount of time and effort have been expended on improving the burden by sizing and sintering the ore, sizing the limestone, the use of lime-sinter, and higher quality coke. Only in recent times has much thought been given to the air, other than constant volume and pressure. Weightwise it is one and half times heavier than the ore changed. (This is based on actual operation of our No. 4 blast furnace on June 30, 1958.) From this standpoint it rates serious consideration, for each variable eliminated improves furnace regularity and efficiency.

For a great many years moisture was considered detrimental rather than beneficial in a blast furnace and precautions were taken to eliminate leaks in water cooled valves, usually being detected by above normal hydrogen content of the gas produced. In some areas the blast was dehydrated by means of refrigeration to lower the moisture content. One of the more recent innovations has been moisture addition to the blast by the introduction of live or exhaust steam. It is used in varying amounts to meet the requirements of different operators, per se, or in conjunction with oxygen. At Weirton, the latter is used.

To emphasize the importance of moisture control, see Figure 1 which shows the wide range and the frequency of moisture fluctuations with the time of day and with the season. This was recorded in the Pittsburgh area during January and July of 1950, based on dew point reading taken by the U. S. weather bureau at six-hour intervals. Note that the units of measurement are grains per cu ft, to conform to standard blast furnace terminology, and not in relative humidity as used by the weather bureau. The moisture variation is from 0.75 grain per cu ft in January to 7.75 grains per cu ft in July. This seven grain span of moisture has a definite effect on furnace regularity, thus establishing a need for a constant moisture content.

It has also been established that increased moisture is required when enriching the blast with oxygen. Table I is a working relationship between oxygen enrichment and moisture content at 1150 F hot blast temperature.

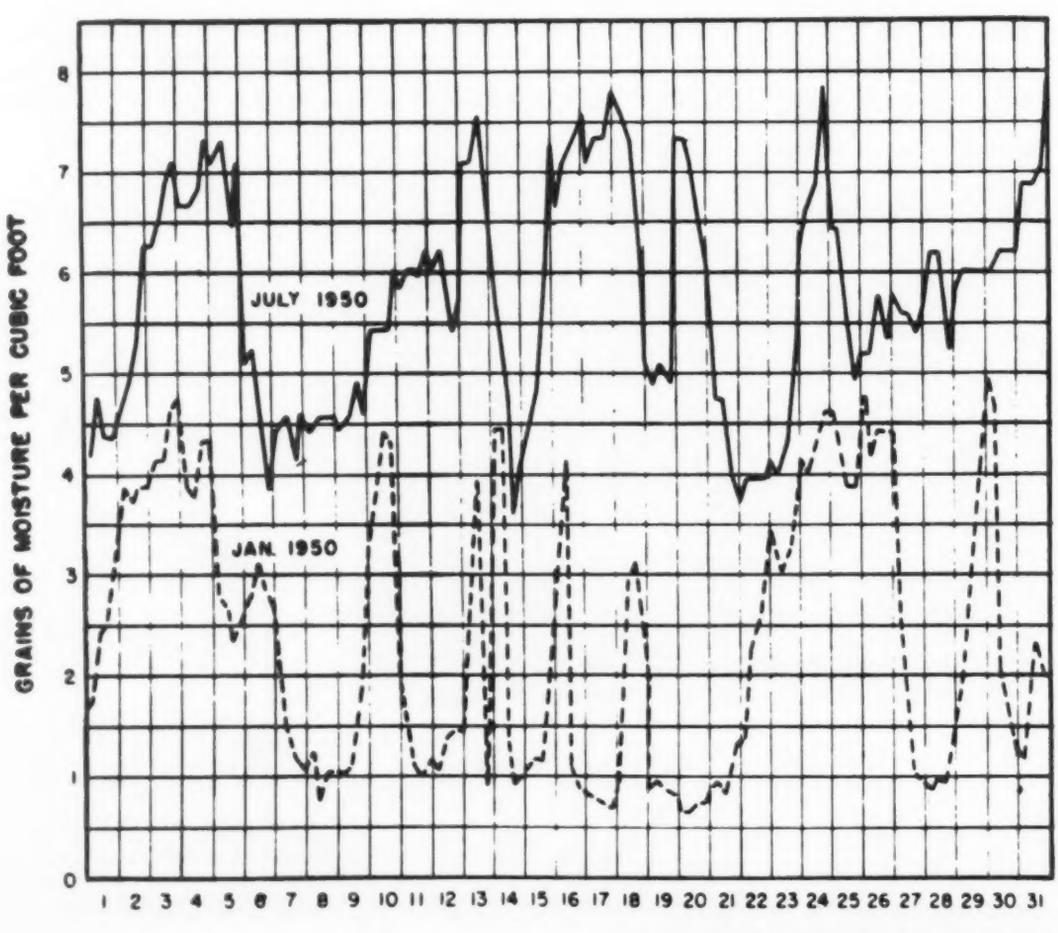

Figure 1 — Normally the moisture in the blast is a function of the daily humidity.

And Moisture To A Blast Furnace

by J. L. WALLACE,
Assistant Superintendent
Fuel Dept.
Weirton Steel Co.
Div. of National Steel Corp.,
Weirton, W. Va.

. . . . changes in moisture have an effect on blast furnace regularity-control and should therefore effect a decrease in coke rate, and an increase in iron production . . . .

Another factor which determines the amount of moisture which can be used is the available heat from the stoves. Above 1150 F hot blast temperature an additional 30 degrees is required for each grain of moisture, due to heat absorbed in dissociation within the furnace. On this basis, for 3.5 per cent oxygen and 1600 F hot blast temperature, 27 grains of moisture would be required.

For convenience oxygen and steam are added at the blowing rooms and the controls for each are operated and serviced by the same personnel. There being no relationship between them at this point, they will be described separately beginning with the moisture.

Repeating from a previous paragraph, moisture addition can be made by introducing live or exhaust steam into the cold blast. In using exhaust steam, due to the pressures involved, it is necessary that it enter the blast air before the turboblower. Heaters must be provided to prevent freezing in the intake during cold weather. Although equipped to use exhaust steam, normally we use live steam, and introduce it into the cold blast main after the blower. The moisture content required is determined by the operating department of the blast furnace and relayed to the blowing room, to an employee of the fuel department who changes the set point of the controller to meet these requirements.

The control system consists of a moisture detecting device, a recorder-controller and a control valve. The heart of the system shown in Figure 2 is the detecting unit, a humidity sensitive element which measures water vapor pressure through a temperature system. This is a very reliable component and merits an explanation.

The atmosphere exerts a pressure on anything with which it comes in contact. There is always water vapor present in the air, so a part of the atmospheric pressure is exerted by the water vapor content. This is the partial pressure of the water vapor and is a measure of the volume of water vapor in the air.

There is a continual interchange of molecules in every aqueous solution between the solution and the atmosphere, resulting in a solution vapor pressure dependent on the temperature and composition of the solution. There also is a relationship between the temperature of a saturated salt solution and its vapor pressure.

To express it in a different way, there is a point of equilibrium temperature for any given water vapor pressure where the molecules leaving the solution equal the ones re-entering it. The water associated with the salt exerts a vapor pressure equal to the partial pressure of the water vapor in the atmosphere. Therefore the temperature of the salt and its water of saturation at equilibrium is a measure of the partial pressure of the water vapor present in the atmosphere. Increasing the water vapor in the air increases the vapor pressure and causes the water molecules to move to the salt solution with its lower vapor pressure. Raising the temperature of the salt solution brings it to saturation at a new and higher equilibrium temperature. The same applies in lowering the water vapor in the air. Some of the temperature must be dissipated to restore equilibrium.

Downstream from the blower is drawn a sample of the blast air this is fed past a detection device to activate a controller. This tap must be located far enough from the point of steam introduction to assure

TABLE I

O_2 Enrichment per cent	Moisture—grains per cu ft
1.0	5
1.5	6
2.0	7
2.5	8
3.0	10
3.5	12
4.0	14

Figure 2 — A humidity sensitive detecting unit actually determines the water vapor pressure of samples to permit blast moisture control.

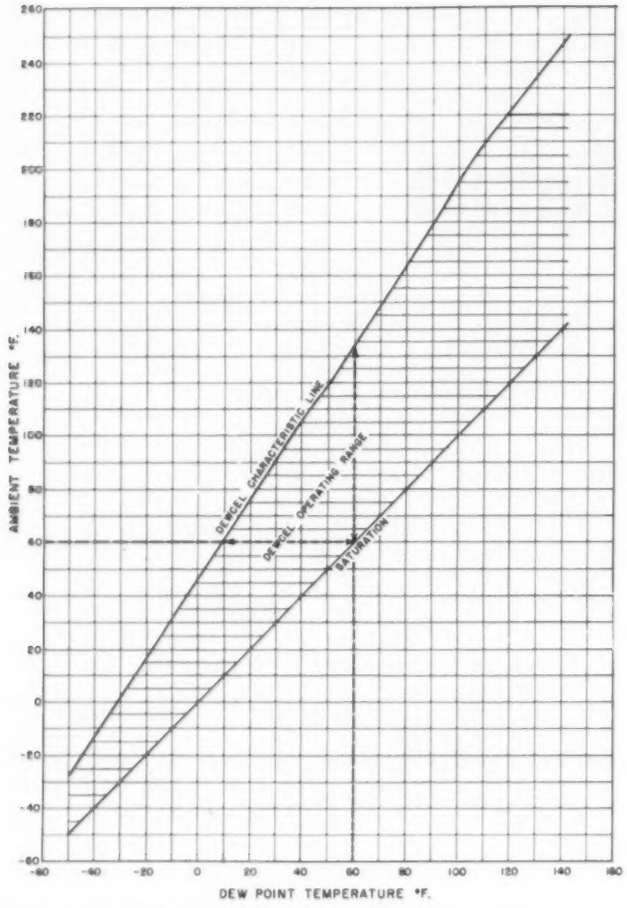

Figure 3 — The operating range is between saturation at dew point and a characteristic curve for the device.

proper mixing. Otherwise erratic readings and unstable control may be obtained. This sample line must be insulated to maintain the temperature of the sample above dew point to meet the requirements of the instrument.

The operating range of the detection device is illustrated by Figure 3.

The lower curve is saturation at dew point temperature, and the upper curve is the characteristic line. The operating temperature is not critical, but must be held at some point between the two curves. For example, a 15-grain sample would have a dew point of 90 F and a characteristic temperature of 180 F. Any operating temperature between the two would suffice but as a point of arbitration one halfway between the limits or 135 F is selected.

Constructionwise the element is a varnish insulated metal tube housing a temperature element. (This can be a thermocouple, gas filled bulb or a thermohm element.) A wick of woven glass tape surrounds the metal tube and two parallel gold wires are spiraled over the tape, the ends of which are attached to a terminal block for convenience in connecting to a source of alternating current. The wick is impregnated with a hygroscopic salt, lithium chloride, which when dry is a nonconductor of electricity. This point is the threshold of the highly technical theory of ionization and equilibrium of which only the barest essentials will be described.

Keeping in mind the fact concerning equilibrium temperatures, these wires will only pass current at or below equilibrium temperature. The passage of electrical current through the thin salt solution raises the temperature almost instantaneously to a new equilibrium temperature. In this manner the salt acts as a self-regulating controller to vary the current over a wide range supplying the necessary heat to maintain the salt at equilibrium temperature. This temperature is a measure of absolute humidity of the ambient atmosphere, and can be recorded on a standard temperature instrument. Appropriate tables are available to convert these temperature readings to any standard method of measurement (relative humidity, absolute humidity, or dew point). In our case, as stated before, it is recorded in grains per cu ft.

The power pack supplying the heater current for the temperature device consists of a stepdown transformer and a ballast resistor. The transformer drops the line voltage to 25 volts on the secondary winding. The ballast resistor which limits the starting current is a 30 volt, 50 watt light bulb. In operation the lamp glows until equilibrium is established. After that it should not glow unless a surge of current is necessary to heat the instrument due to a substantial increase in humidity.

The recorder-controller has a 3 to 15-psi output, with proportional band, plus reset, plus derivative. While under most circumstances the blast is fairly constant and the control is stable, at times of wind checks this type controller will bring the moisture back to control point in a minimum time.

As a means of checking the accuracy of the system, a second temperature measuring device is used to measure the natural moisture content of the atmosphere. The difference between this reading and the amount required to any furnace, times the steam required per grain per hr should equal the reading on the flow meter. The steam required per grain per hr is based on the equation:

$$\frac{\text{wind x differential grains}}{\text{grains per lb}} \times 60 = \text{lb per hr}$$

Roughly this amounts to 640 lb per hr for 75,000 cfm wind. As an example, if 27 grains are required on the furnace and the natural moisture is seven, the makeup would be 20 grains. This, times 640 lb per grain per hr, equals 12,800 lb per hr which should be the reading on the flow meter.

The steam regulating valve shown in Figure 4 is representative of the type used. They are equipped with a positioner for stability due to the large pressure drop across the valve and the air volume requirements to stroke it. Cooling fins and teflon packing are recommended for temperature in excess of 450F. The inner valve is a throttle plug type, top and bottom guided. The seating surfaces are hardfaced to prevent wire drawing. On the two newest turboblowers, there are two steam systems in parallel, differing in size only. The small one is a 2 in. feed line and passes enough steam for about 16 grains addition. The large one is 3 in. and has a capacity of 30 grains makeup.

The oxygen is received from the oxygen plant at a pressure of 2 psig. It is then reduced to 1 psig or less for distribution to the individual turbines.

The control system is designed to proportion the oxygen to the volume of wind blown. It consists of a

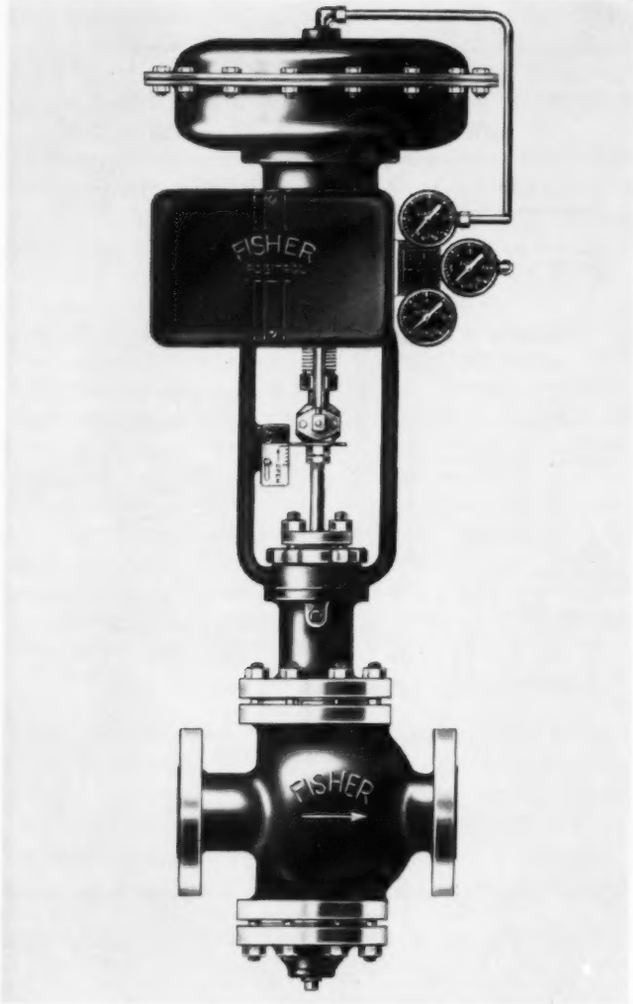

Figure 4 — Accurate addition of moisture is accomplished through the use of a steam regulating valve.

ratio regulator receiving its impulses from the air venturi and a flat plate orifice measuring the oxygen. The ratio regulator in turn positions a valve shown in Figure 5 governing the oxygen feed. The amount of oxygen required is also determined by the blast furnace operating department. Any increase in oxygen over one per cent to a furnace is made slowly, usually in increments of 0.1 per cent to allow time for the furnace to adjust itself. At the same time moisture is being increased according to the table previously shown. Any adjustment can be made by turning the handwheel which changes the ratio between the oxygen/air diaphragms and their effect on the piston controlling the valve. Appropriate tables and correction factors for purity are posted to facilitate making changes so the operator does not have to solve a difficult equation. This is based on the formulae:

W_a — wind blown actual, cfm
O — oxygen added, cfm
W_e — wind blown enriched, cfm
0.209 — per cent oxygen in air
0.95 — per cent oxygen purity

$$\frac{0.209\ W_a + 0.950}{W_a} = O_2/W_e \text{ per cent}$$

In actual practice the blast to No. 4 blast furnace has been enriched by 4 per cent. This is the limit which

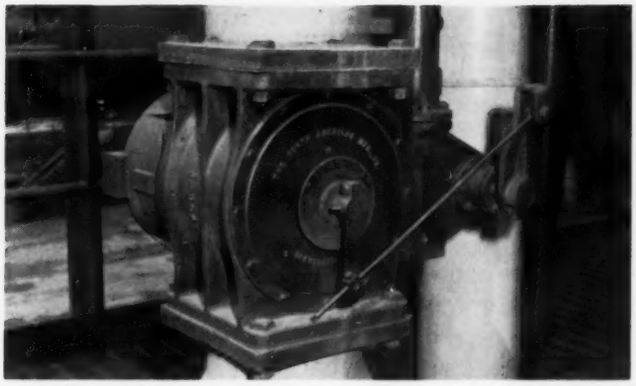

Figure 5 — Oxygen is fed in a ratio to the wind volume by a ratio regulator controlled valve.

can be attained at the present time due to the size of the oxygen pipeline.

One of the most pronounced effects of oxygen enrichment and moisture, as far as the fuel department is concerned, is the low nitrogen and higher hydrogen content of the blast furnace gas produced. This raises the Btu from a level of 95 to 105 to 112. Since much of this gas is consumed at the soaking pits and coke plant, it is of utmost importance that they should be notified of any changes of oxygen usage so that they can compensate for it, because it requires less coke gas to maintain the correct Btu.

The flow meters associated with the steam and oxygen are of the bell and displacer type receiving their impulses from flat plate orifices. The differential pressure of the oxygen meter is 14.3-in. water column, while that of the steam is 120 in. Several orifice plates of various capacities are available to meet the demands of operation and keep the meters reading within a desirable range.

The use of oxygen and moisture in the blast has proven highly satisfactory in increasing pig iron production. Increased stove capacities, larger feed lines for oxygen, plus the experience gained by seven years operation, point to a bright future for this practice.

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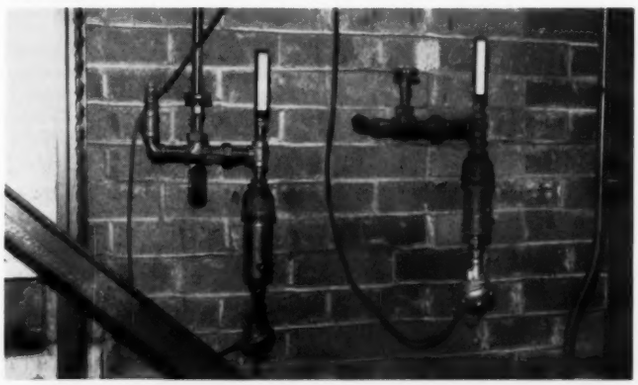
2. W. Bleloch, Journal of the Chemical Metallurgist and Mining Society of South Africa, 1950, pp. 252–292.

Figure 6 — New holder prolongs life of lithium chloride coating.



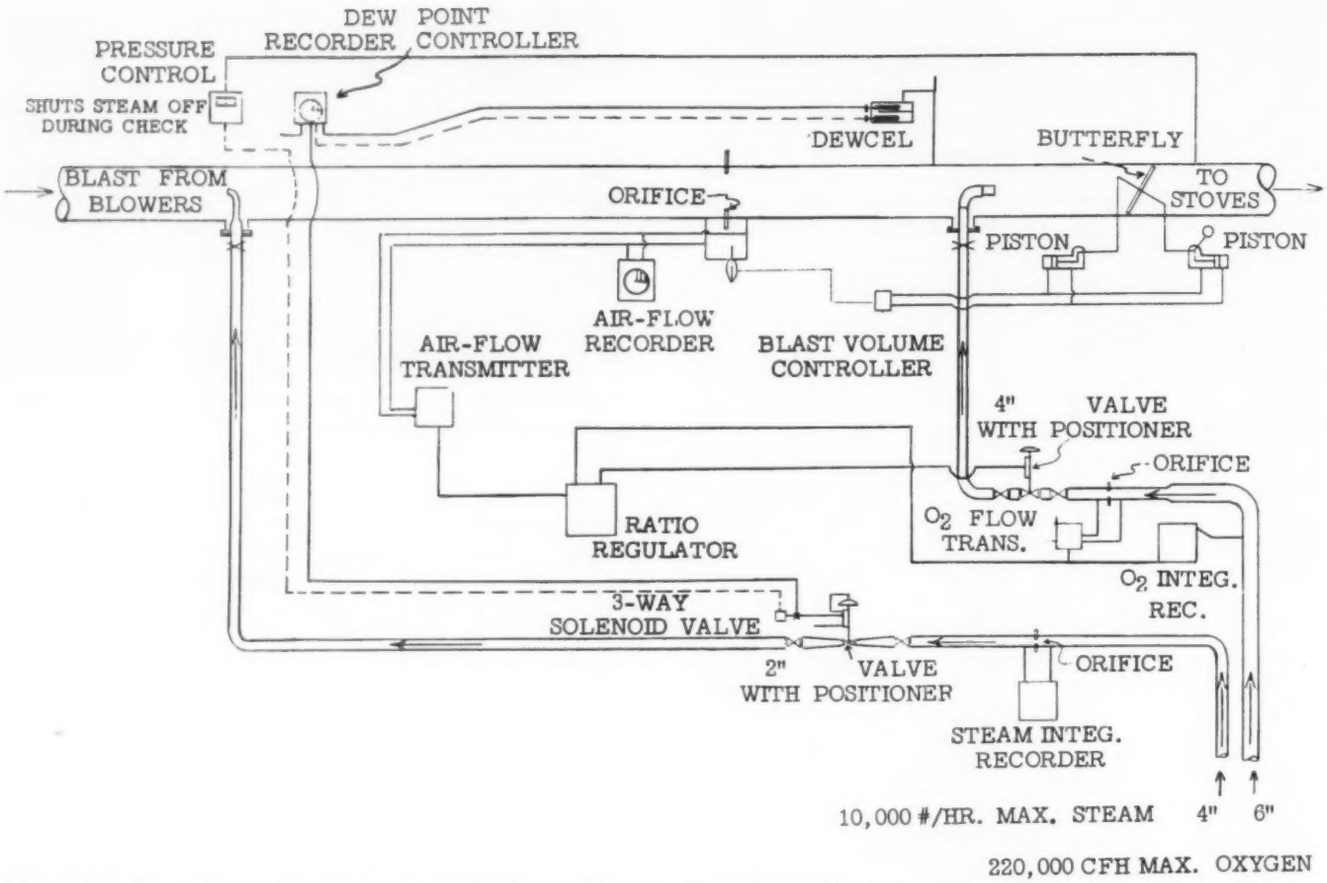


Figure 7 — Flow scheme for moisture control shows placement of the humidity measuring device sampling tube downstream from the steam in-put line and the main orifice plate.

Discussion

PRESENTED BY

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DR. T. E. DANCY, Research Supervisor, Graham Research Laboratory, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

O. J. LEONE, Consulting Engineer, West Newton, Pa.

F. JOLLY, Industrial Engineer, The Detroit Edison Co., Detroit, Mich.

H. B. FALL, General Supervisor, Industrial Engineering, Homestead District Works, United States Steel Corp., Munhall, Pa.

W. O. Bishop: We at Inland have been watching Weirton's experiments with oxygen and steam for some time. We have been using steam on one of our furnaces with a controlled method for about a year and a half. More recently we have been considering the addition of oxygen.

With our experience with steam, we have gained five per cent increased productivity on the furnace but we have also had a few things occur in line with the instrumentation which might be worth mentioning.

Some improvement to the original steam injection installation at Inland was made for a better mixing of the steam and blast at the point of injection. At first the nozzle was a simple coupling welded to the shell and not projecting into the cold blast main. Presently a nozzle projects into the main at a 45-degree angle and directs the steam against the flow of blast. The steam hitting the blast creates a turbulence and increases the mixing of the steam and cold blast.

Further improvement was made at the point of sampling. The full flow of the cold blast at high moisture levels would exhaust the solution of the humidity sensing device after a short period of operation. With the installation of a regulator which controlled the cold blast sampling and limited the total moisture passing over the device, the life of one coating was appreciably extended. Present life of one coating is approximately five days.

Also, the installation of a temperature control on the steam tracer line along the sampling line assures the proper temperature control of the sample and stops moisture fall-out in the sample line.

It was found that the proper installation of the sampling system with regard to location, distance from sampling point, dirt, etc., was very important since the detection system was very delicate.

J. L. Wallace: There have been some improvements made in our sampling systems over the original installation. Under some conditions it was found the correct

operating temperature of the humidity measuring device could not be maintained, due to the heat being dissipated by the hood. A new holder or hood was designed, using standard pipe fittings, which has proven superior to the original.

There are six devices in operation at our plant, and it is a relatively simple operation to check one against another. At present we have no set schedule for replacing them or the solution on the element. The new holder as shown in Figure 6 limits the flow past the device, prolonging the life of the lithium cloride coating.

Dr. T. E. Dancy: It has been interesting to hear in some detail the controls used for adding oxygen and steam to the blast of blast furnaces at Weirton. It seems appropriate to describe the type of controls which were fitted to a blast furnace at the Aliquippa Works of Jones and Laughlin for carrying out a full scale trial with similar operation over a period of several months last year. These controls were in some ways similar to those used at Weirton and also like those described by Mr. Bishop, but arranged so that the minimum alteration was necessary to the normal blowing controls. In addition, the oxygen was 99.5 per cent pure and required care in its use. Figure 7 shows the flow scheme.

The furnace is fitted with a split wind blowing control which divides the output from three manifolded turboblowers between three furnaces. The diagram shows the butterfly in the cold blast line which controls the blast volume on the furnace. The volume is measured by the orifice plate which provides a signal to control the blowing rate and also a signal to proportion the oxygen which was metered by an orifice plate in the oxygen line. The steam was controlled in the same manner as at Weirton. Thus, the sample was withdrawn downstream from the cold blast main orifice plate, but upstream from the oxygen input nozzle. The steam, controlled by the temperature measuring device, to maintain any preset total moisture level was introduced into the cold blast main far enough upstream from the orifice so that there was adequate mixing. In addition, we curved the steam nozzle upstream in the same manner as described by Mr. Bishop. Total and instantaneous steam volume required to maintain the preset moisture level were measured by an orifice in the steam line. An automatic steam shut-off was provided when blast pressure dropped below any preset value. The oxygen line was 6 in. in diameter to keep the gas velocity below a safe rate when operating at the maximum oxygen rate (150,000 cu ft per hr). The oxygen was introduced into the geometric center of the 48-in. diam cold blast line through a stainless steel nozzle curved downstream. Since the cold blast main was not particularly clean we had to be very careful that the high purity oxygen did not impinge against the walls; however, with the arrangement used we had no difficulty with spontaneous combustion.

This system worked extremely well over a period of several months giving very little maintenance trouble and gave precise control over the whole range of blowing rate encountered in normal blast furnace operation.

We have already published the results of this trial [1].* The author indicated that a factor which determines the moisture which can be used is the available heat from the stoves. This is not strictly correct especially when steam additions are associated with oxygen enrichment. The trial at Aliquippa showed that with increased driving rate due to oxygen enrichment, despite the fact that some increase in moisture was necessary, there was actually a decrease in coke rate at constant blast temperature. This is similar behavior to that at Weirton. The factor which really determines the moisture which can be used is the available heat in the furnace to smelt the iron. This available heat is affected by many factors such as driving rate, slag volume, ore composition, as well as blast temperature. The data obtained during this trial showed rather conclusively that the amount of heat required in the furnace to produce a unit of iron from the same burden is constant irrespective of blast composition.

In the trial, optimum conditions with 1.5 per cent enrichment were obtained with only 5.1 grains of moisture per cu ft in the blast giving an increase in production of 9.2 per cent. However, in contrast to Weirton experience, the furnace seemed remarkably insensitive to rapid changes of oxygen addition. In fact, oxygen at a rate of 30,000 cu ft per hr could be put into the blast instantaneously without cutting back the blast. Increases in succeeding hourly intervals of 30,000 cu ft per hr up to 90,000 cu ft per hr (about 1.5 per cent enrichment) did not result in any undue increase in blast pressure or hanging even though the normal full air wind rate of 79,000 cfm remained unchanged. Even up to 150,000 cu ft per hr (about 2.5 per cent enrichment), it was not necessary to cut back on the normal full wind rate though some short periods of high blast pressure were encountered.

O. J. Leone: We have had no direct experience in the combined injection of oxygen and moisture into the blast furnace. However, we had some experience during World War II with steam injection only, at which time we developed what was probably the first closed-loop absolute-humidity control system based on measuring the blast humidity of the blast at a point in the cold blast main after the controlled steam was injected into the blast main on the pressure side of the turboblower. The results of this work were reported by me, in the 1946 AISE Proceedings.

The practice of steam injection was somewhat controversial at that time and, in fact, from about 1939 to 1942 the practice of drying the blast had been revived to the extent that more than twenty dry-blast installations were made in this country and abroad. Most of these installations are no longer in operation.

It has been interesting to note the change in the opinions of most blast furnace operators over the years on controversial practices such as dry blast, wet blast, and later, on high top pressure operation, and that only in recent years have steam injection and top pressure been accepted as good practice in this country. This reluctance and delay in adopting new practices appears to be characteristic in the U. S., while ironically some developments which originated here have been more readily and widely adapted abroad. Such has been the case with absolute humidity control of steam injection, pressure operation and differential pressure control, on which it is reported that Soviet Russia in particular has many more installations than we have.

On the first wet blast installations, operation was

* Numbers in parentheses refer to Bibliography at end of paper.

difficult because the instruments available at that time were not capable of measuring absolute humidity of the blast, and particularly under the temperature and pressure conditions that exist in the blast main. The above development solved these problems, but some of the installations were adapted to dry-blast systems as well as to wet blast systems.

In recent years more consideration has been given to the use of steam injection in our country in conjunction with the use of an enriched oxygen blast. Control systems such as described in the paper by Mr. Wallace have been adapted for the combined control of steam and oxygen injections. As a consultant to the manufacturer of the dew-point system described in the paper, we had the pleasure of assisting with the first applications of the chemical dew-cell method. Weirton Steel Co. pioneered in the successful application of the combined steam injection and enriched oxygen techniques in this country, and deserves much credit for this effort.

From several recent reports on oxygen enrichment tests, apparently Weirton Steel Co. has successfully used a greater maximum oxygen enrichment than the maximum enrichment reported recently by Jones and Laughlin Steel Corp. The latter indicated that in one test at least, that oxygen enrichment greater than about 2 or 2½ per cent resulted in hanging or slipping of the furnace.

F. Jolly: I would like to confirm my impression that there is about 10 Btu per cu ft increase in the heat content of the blast furnace gas with oxygen and steam enrichment of the blast.

J. L. Wallace: The gas produced will have a CO/CO_2 ratio of about 1.71 average with 3 to 4 per cent oxygen enrichment.

The top gas for No. 4 furnace with 4 per cent enrichment and 50 per cent sinter averages:

CO_2	16.7 per cent
CO	28.4 per cent
H_2	5.6 per cent
N_2	49.3 per cent

This will confirm Mr. Jolly's impression that there is an increase in Btu in the blast furnace gas.

Dr. T. E. Dancy: On this question of total Btu's in top gas available per ton, this depends very much on the burden being used. This will affect the coke rate, but, as a rough guess, that with the sort of improvements that have been achieved at Weirton, the number of Btu's available per ton of iron produced would actually decrease over that which would be obtained with normal operation despite the increase of Btu's per cu ft of the top gas.

On the other point on the limitation of the maximum amount of oxygen which could be used in the blast furnace, we certainly did not run long enough at a high level of oxygen to determine this. However, there does not seem to be any chemical reason why it should not be possible to add oxygen and steam up to a very high level provided sufficient steam was added to maintain a low enough tuyere zone temperature; the barrier will be an economic one long before it is a chemical one. The point here is that air is much cheaper than oxygen and unless there is a very good reason why you cannot get at least some air through the furnace you would not operate on oxygen and steam alone. It is worth mentioning that there was a paper published in South Africa by W. Bleloch in 1950[2] which outlined a method of operating a blast furnace using an oxygen/carbon dioxide blast which seemed very reasonable on a theoretical basis. Sufficient CO_2 was added to keep the flame temperature in the front of the tuyere down to a reasonable level.

O. J. Leone: One of the companies with whom we worked about 12 years ago wished to inject steam into the blast main, but as they had a shortage of steam boiler capacity, with them the possibility of injecting spray water directly into the hot blast side of the blast main was studied. However, this was decided to be impractical, for the reason that the sensible heat in the water would be just a very small part of the total heat required to vaporize the water, and the heat requirements might rob too much heat from the hot blast. A further complication was that the stove capacity was not too great. Thought also was given to the possible effect of unvaporized water which might fall on the hot blast main refractory lining. For this plant at least, the idea was dropped.

During the second world war, the late J. R. Fulton also discussed with us and with others the possibility of injecting steam at the hot blast side of the stoves, and in sufficient quantities to saturate the blast. While this appeared to be entirely feasible with our control system, the measuring and control problem would be more difficult as compared with the steam injection system shown by Mr. Wallace, which is generally similar to the one that we used. For example, to measure the absolute humidity of the air in the hot blast main would require the handling of sampled gases at temperatures as high as 1200 or 1300 F, instead of at only several hundred degrees in the cold blast main. While our system was capable of handling 1200 F air, which we would cool to a constant dry bulb value of 125 F by our method, actually, the highest temperature that we experienced in the cold blast main was a high value of 470 F. This occured on a dry-blast installation under conditions when the turbo-blower was "pumping" during furnace hanging conditions; at this these temperature conditions the instruments performed satisfactorily.

It may be of interest to mention that we sold the first absolute humidity control systems to Soviet Russia during the second world war, for wet blast applications, after they had learned of our instrument development for this measurement in this country. Six of these systems were purchased by the Russians through Lend-Lease arrangements. We later learned that the Russians built their own copies of these instruments, and eventually equipped about 90 per cent of the blast furnaces with the method. Although the method was developed in this country, the Russians were faster to adopt steam injection control.

J. L. Wallace: Water injection is very interesting if it were only practical. It is also interesting to note how long moisture addition has been practiced and the various methods used. From most reports one would gather that Russia uses moisture additions on many more operations than the U. S.

H. B. Fall: Mr. Wallace mentioned that he took the oxygen off of two furnaces. Would he care to comment on the reason for that?

J. L. Wallace: At the present time the open hearth has priority on oxygen due to its use on roof lances. ▲

Data Accumulation Techniques
Applied to Processing Lines

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. . . . the techniques of data accumulation will provide a foundation for future extensions of automatic control systems on steelmaking processes . . . .

WITH the extension of programmed control to main and auxiliary drives, the entire potential of the completely automatic mill becomes more apparent. Realization of this ideal depends, in part, on advancements in the art of data accumulation and feedback systems so that information can be compiled as to the actual characteristics of the process.

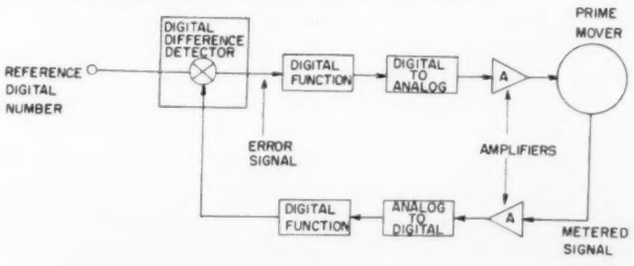
Initially, data accumulation systems were used in the mill accounting procedures related to the determination productivity and product quality. Today, they represent a means for expanding knowledge of mill process characteristics in order to accomplish future extension of automatic control systems.

STATE OF THE ART

This expansion may best be illustrated by a discussion of the growth of digital feedback control systems. The earliest application of digital techniques in the control system was the construction of digital servo feedback systems. As shown in Figure 1, the digital servo consists of an analog to digital signal conversion unit which presents information pertaining to the state of the prime mover in digital form. This information may be acted on numerically to perform various functions such as nonlinear correction rates on the systems. The resultant information is subtracted numerically from a digital reference, the difference being the error signal. This signal is converted back into analog information to directly control the prime mover in terms of position, speed, frequency, voltage, current and other parameters. The advantages of the digital system over the analog are its greater precision, speed of response, adaptability to use special functions and the fact that the digital reference may be directly programmed from a sequence of stored numbers.

The programming feature of the digital servo is the key to the programming system and is illustrated in Figure 2. A sequence of numbers, stored in some medium such as a punched card, punched tape, magnetic or electric memory, or by manual operation, is presented

Figure 1 — The general digital feedback controller consists of an analog to digital signal conversion unit.



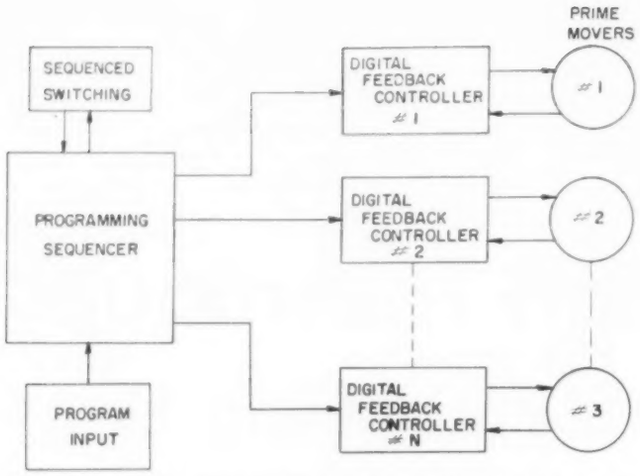


Figure 2 — Programming is the key to the system.

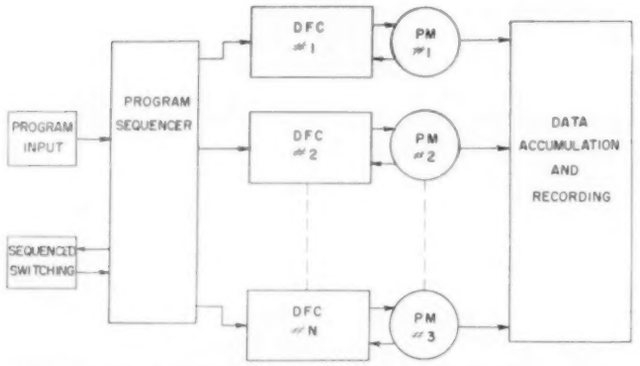


Figure 3 — Data accumulation evaluates production capabilities of operation.

to one or more servos by a memory scanning device. An example of this in actual operation is the programming of reversing roughing mills through the use of punched cards.

To evaluate the production capability of such an operation and to determine if the actual product is that asked for, a data accumulation system may be applied to the programming system as shown in Figure 3. It is important to note that the information sought is that pertaining to the product itself and not the control system. It is assumed that the servo will do as it is commanded when working correctly. Observation of the control performance is, therefore, a checking and maintenance function and not one pertaining to product information.

The final step in completely automating a mill is to use the product information accumulated to automatically rearrange the programmed information in a manner to optimize the over-all system. The construction of a program re-evaluator to close the information feedback loop, as shown in Figure 4, is ideally suited to a digital computer of some form. Through use of multiple correlation, linear regression and other means of examining data, the program re-evaluator constantly attempts to optimize the system as more information is learned about it.

The information self-optimizing feedback, as it exists today, is only a rudimentary form. This expansion is basically limited by the lack of information concerning the detailed operation of the processes themselves, not the limitation on computer technology. The gathering and processing of information is a prime requisite to the ultimate automatic processing line.

In this light, the data accumulation system becomes a means for acquiring and utilizing the required information as well as being an accounting and product identification vehicle.

FUNDAMENTALS OF THE DATA ACCUMULATION SYSTEMS

Specifically, data accumulation systems, as they are known today, perform five basic functions:

1. Sense information pertaining directly to the product.
2. Coordinate the information with physical location in the product.
3. Accumulate the information and store it in a predetermined pattern.
4. Address the stored information with a sequential readout, for permanent record, upon demand.
5. Insure reliability and simplify maintenance.

The inter-relation of these functions are shown in Figure 5 in block form.

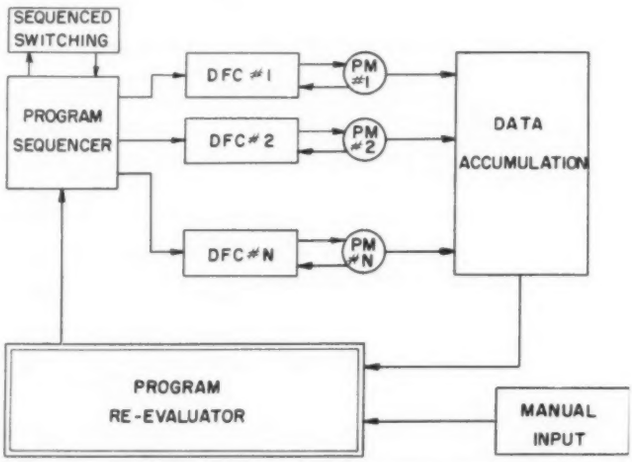
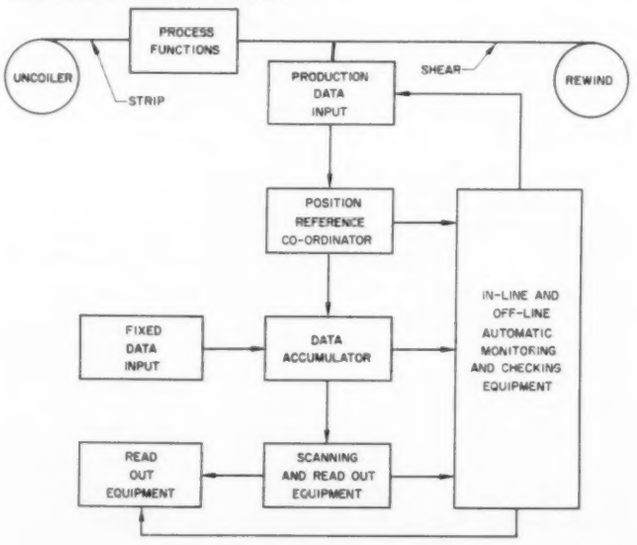


Figure 4 — For the completely automatic system the loop must be closed.

Figure 5 — Schematic shows elements of basic processing line accumulation system.



Information pertaining directly to the product may be received in the form of fixed data and production data. The fixed data is derived from such sources as a card reader and manually selected schedule information. The production data is that which will be inserted into the system during the processing of each individual coil and may be obtained from sources such as the pulse tachometer, visual inspection stations, automatic defect detectors and weighing stations.

If the fixed data is received in the form of punched cards, a card reader will function as a means of inserting the data into the system for combining with the production data to form a complete record on the individual coil. In addition, the punched card, through the card reader, may be used to program the strip thickness and coating weight detectors for the individual coil base metal thickness and coating weight. For most processing line applications, the fixed data for an individual coil can be incorporated on one punched card; therefore no memory unit is required and mechanically actuated switches will usually prove to be satisfactory. Since the unit will probably be located in the mill area, consideration should be given to dust-proof features of the reader. The requirements of the basic system may be such that provision must be made for the carded information to be manually overriden by means of selector switches mounted on a desk as shown in Figure 6. If this function is included, the switching voltage should be in the range of 48 to 110 volts in order to minimize the effect of contact resistance and reduce the effect of induced voltages. The polarity of the basic system should be extended to the switching circuit and compensation for a difference in potential between the switching circuit and the basic system could be made by an R/C network with the side benefit of high frequency noise suppression realized.

The basic timing pulse for all production data is provided by the pulse tachometer, a typical one of which is shown in Figure 7. Two general types, which we will identify as (1) rotary transducer strip driven type and (2) magnetic proximity type, are available. The general application of the second type is limited in that the characteristics of the device are such that it becomes insensitive below strip speeds of 150 fpm. A selection of the first type should satisfy the following requirements:

1. Rugged, totally enclosed, for steel mill duty.
2. Mechanically duplicate for all rotor-stator combinations. The pulses per revolution output is determined by the rotor-stator combination and is selected on the basis of system accuracy desired.
3. Capable of maintaining total footage count through use of a sequence detector and reversible counter in the event of strip creepage in either direction.
4. Square wave output with a time of rise such that the null zone is minimized and of a value in the order of 5 microseconds. Also, the output pulse should be of sufficient amplitude to operate directly without an external amplifier into a transistorized shift register or counter. The pulse width error should be in the order of 1 per cent.
5. No brush type contacts should be used in the rotor circuit because of the low energy levels involved.
6. Amplitude and shape of the pulse are not dependent upon the speed of rotation.

A view of the internal arrangement of a rotary transducer strip driven type pulse tachometer, showing the rotor and stator assemblies, is illustrated in Figure 8.

Visual inspection signals should be obtained from pushbuttons having the same electrical characteristics as those described for the manual selector switches. In addition, if visual indicators are associated with these pushbuttons, the indicator signal should be

Figure 6 — Card information can be manually overridden by selector switches.

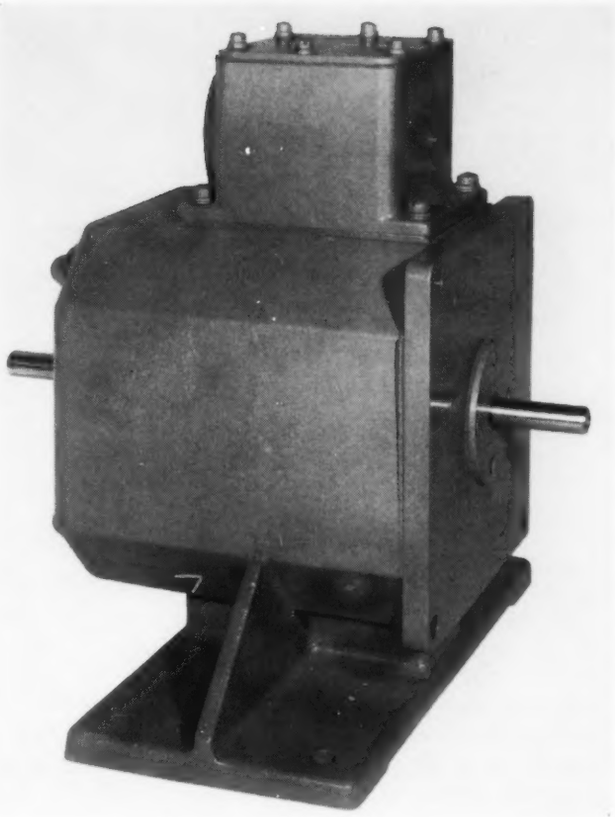


Figure 7 — Pulse tachometer provides basic timing pulse

received from the system and not the switch in order to insure correct system operation.

Other sensing devices, are required to determine the quality of the product directly. New developments in noncontacting gages, to be announced in the near future by builders of these devices, indicate a wider use of these devices; however, at the present time, the most commonly used devices perform the following functions:

1. Base material thickness measurements.
2. Coating weight measurements.
3. Pinhole detection.
4. Coil weight measurements.

Some less common functions include:

1. Matte surface detection.
2. Strip width measurements.
3. Temperature measurements.
4. Hardness measurements.

On the basis of these measurements, strip increments of predetermined length are to be designated prime, mender and waste-waste with the data of varying nature collected on each increment. Insofar as the data accumulation system is concerned, the sensing devices should have the same general characteristics of (1) electrical isolation between the sensor and the data accumulation circuits, and (2) an output circuit having a pickup time of a value less than the time required for the given strip increment to pass a designated point. In order to satisfy the time requirement, it may be found necessary to modify the output circuit by means of a transistorized NOR element.

COORDINATING DEVICES

Since the sensing devices obviously cannot all be located in a single physical area, the sensed information must be coordinated with a predetermined reference point such as the shear. The most straightforward means of performing this coordination is by the use of static shift registers. These consist of chains of binary bits which may be shifted simultaneously down the length of the chain. Each bit is used to represent an increment of strip (one foot). Information from sensing devices is entered directly into the shift register bit that represents the location of the particular device. If coil profile data is required a separate shift register, having a length equal to the transducer's distance from an auxiliary reference point, is required for each sensing device. If coil profile data is not required, only a single static shift register need be used.

The operation of a shift register may be demonstrated in analogy by considering a hollow tube filled with a column of white (prime) balls each of which represents a binary bit or an incremental length of strip. As each new ball is inserted in the tube, the entire column is shifted the diameter of one ball. At a position in the tube, pinhole inspection is made between shift signals by removing, inspecting and replacing a white ball if no pinholes are found. At another position down the tube, strip thickness is measured. The respective ball is removed and a black one is inserted if the increment contains off-gage strip. If a pinhole defect had preceded the off-gage for that increment, a black ball would have

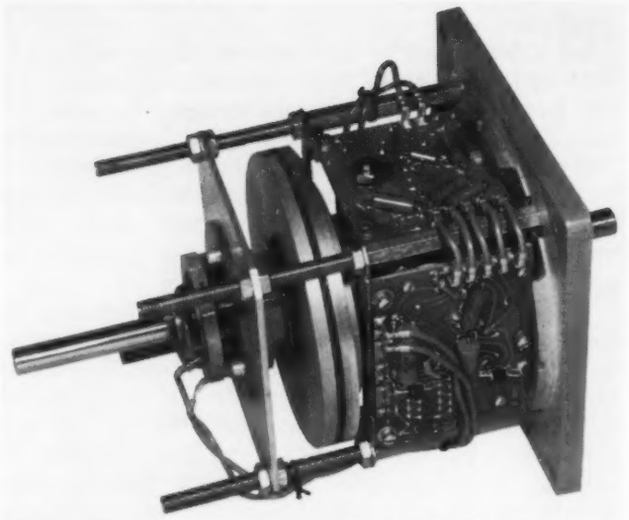


Figure 8 — Rotary transducer strip-driven type pulse tachometer.

replaced a black ball and the defect information would continue to register one defect foot regardless of the number of defects per foot. Every time a black ball is inserted into the tube from a sensing device, registration is made in the respective defect counter to indicate the number of feet of that type defect. As each ball drops out of the lower end of the tube, a count is entered in the total footage counter. In addition, an examination is made and for each white ball or "zero," a count is entered in the prime footage counter.

The mechanical methods of referencing sensors, such as punched paper or magnetic tape synchronized with line speed, are not reliable enough at present for industrial use. Other methods can be used if a computer is incorporated in the data accumulation system, provided speed and storage space of the computer are adequate.

DATA ACCUMULATOR

The signals received from the sensing devices and input information entry must be continuously stored and accumulated in some type of memory register. The following four types of memory have been used for this purpose:

1. Solid state, static counters.
2. Magnetic core storage.
3. Dynamic counters and flip-flops.
4. Magnetic drums.

The first two devices have been used in industry for some time now in on-line controls such as programmed reversing roughing mill. The inherent reliability of these devices is proved in mill service. The latter two types have been used primarily in business type data processing systems and have not yet proved their merit in industrial type systems. Further, the magnetic drum is a mechanical device that requires extremely close physical tolerances in its design. Recent trends in the industry have been toward more static devices.

PROGRAMMING AND READOUT OF INFORMATION

On demand by the line operator, particular sets of data in the storage section must be read out to output

devices. The information stored in memory is in parallel registers. Each register may be scanned at will from a static central programmed scanner. As each register is scanned in the sequence specified by the program, it is entered into a static information converter which changes the stored information into a form compatible with the particular output devices used and the particular code and format required by the user.

Output devices in present use are:

1. Punched tape.
2. Punched cards.
3. Adding machines and printers.
4. Typewriters.
5. Indicators.

Indications, from experience, point out that the tape punch, with its minimum number of moving parts, is the most reliable of these devices. Therefore, wherever possible a punched tape is first made and then either manually or automatically inserted into tape-controlled typewriters, printers and card punches. Since all of these can be used simultaneously with a punched tape, frequent failure in these business-type devices will not result in a loss of information. The previously prepared punched tape is a permanently stored record. Further, tape perforators can operate at speeds well in excess of the other output devices. This enables fast readout with off-line conversion to other forms using the punched tape as a speed buffer.

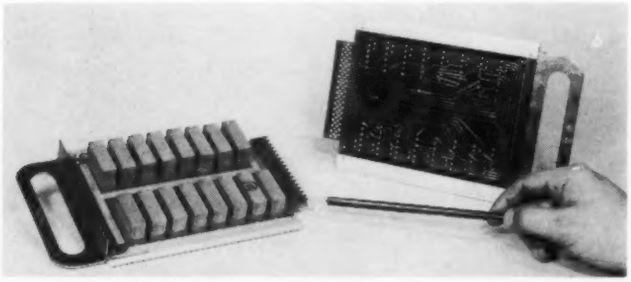


Figure 9 — Module design simplifies construction.

Figure 10—Module assemblies are easily accessible.

Figure 11 — Static type equipment reduces space requirements.

RELIABILITY AND MAINTENANCE SIMPLIFICATION

Although it may be argued that many data accumulation systems are off-line, it is important that they be just as reliable as on-line control. Excessive maintenance requirements will not only discourage use of existing equipment, but when integrated with information feedback control, it becomes on-line. Product quality and other pertinent data, that come to depend on installed systems, require this reliability. This necessitates that the basic system be static and packaged for industrial service, designed to be reliable, packed functionally for rapid failure location and replacement, and have self-testing means to indicate and locate failures.

The basic system must have an inherent reliability in order to inspire user confidence. Redundancy methods, using two or three unreliable systems, might be made to operate as well as the single reliable system on the over-all function basis, but the maintenance on three unreliable systems will be much greater than three times that expected on a single reliable one. On closer inspection, there is a more significant reason for not considering the redundant system. The best strip length measuring devices are no more accurate than 0.05 per cent. On a 20,000-ft coil this means that total footage count may be in error as much as 10 feet. Therefore, loss of a count or two in such a coil is meaningless. In a well designed static system, a count might not be lost in several millions of feet. In this respect, the system is already more reliable than warranted. It is gross breakdown of functions that must be kept at a minimum and functional packaging is the most straightforward method of meeting this problem. Static circuits should be put into single package representations such as the functional module shown in Figure 9. Any failure in the package, regardless of its nature, causes the complete function to operate incorrectly. It is easier to determine a function failure, since it has physical system significance, than

to find a component failure. Rapid replacement of the functional module gets the system operating immediately and the modules may then be repaired off-line. Module design must be flexible so that a minimum number of different types are required, thereby reducing spare inventory.

These modules must be physically packed in such a manner as to make them easily accessible as shown in Figure 10. This is also true of the interwiring techniques which must be as reliable as the rest of the system and accessible for making changes when required. A hinged door arrangement using flexible tape cable for wiring hinges and geographically arranged wire wrap interconnections is one answer to the problem. The inside of a system, showing input interconnection and power supplies is shown in Figure 11. Industrial type enclosures, as experience has dictated, are required. While not contributing to the reliability of the system, appearance of the equipment certainly has its place as shown in Figure 12. This is the same installation shown previously with the hinged d oors closed.

No system built today is one hundred per cent reliable, and since static equipment does not smoke when defective, special equipment must be included to detect failures when they occur and automatically locate the functional source of error. Some of the methods presently used are:

1. Indicator arrays arranged in special forms for easy visual inspection. Important and critical functions can be emphasized.
2. Oscillators used to program predetermined information through the system in order to simulate system operation. The programmed information is read out on the output devices in a matrix form for easy fault identification and location. The whole system, including readout devices, is checked.
3. Sensing devices may be automatically checked by inserting actual faulty material to them. Since the sensing devices, as in all systems today, are the weakest link, redundancy can also be utilized significantly.
4. Self-checking operations, such as determining that prime and defect footage add up to total footage, are simple on-line checks.
5. Critical circuit redundancy has a more meaningful role than system redundancy. Duplication of circuitry throughout the whole system can be mathematically shown to be several orders of magnitude more reliable than duplication of systems.
6. Simplified maintenance and instruction books are absolutely required, since it is expected that user maintenance personnel are to be used. Training sessions after installation are also a must. It is important to know what the system cannot do as well as what it is designed to do.

Figure 12 — Assembly provides for convenient control.

COIL PROFILE

The preceding discussion has dealt with the basic data accumulation system in which no attempt is made to reference the defect information to physical location in the product. A need for this function is suggested by the example where a tinplate producer would attach to the coil a permanent record with which the can manufacturer could program a shear to remove defective strip without an investment in defect detection equipment.

In order to incorporate this function in the basic system, a coil profile system, the main types of which will be discussed here, may be added. Each type must be examined in light of the particular technical and economic situations involved.

Coil profile systems have a common characteristic in that all involve the referencing of defects to a point or points, which cannot be removed indiscriminately, located at the front or tailend of the coil. They may be classified into three categories shown in Table I as: (1) single foot defect, (2) defect strip and (3) continuous chart methods.

The major technical drawback of the single foot defect methods lies in the inaccuracy of present devices used for footage measurement. For example, in the processing of a 20,000-ft coil, the inaccuracy between the producer's and user's measuring equipment must be less than 0.005 per cent for an error of one foot or less. A modification consisting of a correcting reference, which may take the form of a hole occurring at regular intervals in the strip, can be made to compensate for footage measurement inaccuracy. In order to utilize the correcting reference, the user must have hole sensing equipment available. In addition, the basic system design must include an adjustable counter.

Inspection of each foot of product is performed in the single foot defect methods. The results may be recorded on the basis of an increment of paper tape for each foot of product. The quantity of tape involved makes the use of magnetic tape, if it could be made reliable for industrial usage, attractive; however, this not being the case, an expensive, high speed, paper tape punch is required. In order to reduce the quantity of tape and permit the use of slower punch equipment, defect feet information only, addressed by the number of feet from the front end of the coil, is punched into the tape. For example, if a pinhole occurred 413 ft from the beginning of the coil, the number 413 would be punched in the tape along with a code character representing pinholes.

The strip defect methods fall into two broad areas

TABLE I
Coil Profile Systems

I.	Single-foot defect methods
	A. Individual foot record with and without correcting reference
	B. Defect feet only record with and without correcting reference
II.	Defect strip methods
	A. Per cent defect record
	B. Rate of defect occurrence record
III.	Continuous chart methods
	A. Analog input record
	B. Digital spike input record

which are identified as the per cent defect method and the rate of defect occurrence method. Unlike the single foot defect methods in which individual defects are coordinated with a specific one foot increment of strip, the strip defect methods may be considered where the requirement is to detect lengths of strip in which the quantity or frequency of defect exceeds a given maximum. It is suggested that such methods could be utilized on the basis of in-plant quality control where the coil profile would be prepared on high-speed high production mills or processing lines and be used to determine whether a coil would remain in process or be returned to a salvage process which could be programmed by the coil profile record.

In the per cent defect method, predetermined lengths of strip in increments of 100, 250, 500 or 1000 feet are inspected for defects on a total count basis. The ratio of defect footage to total footage would be calculated for each strip increment and recorded on paper tape along with the address of the increment from the coil reference point.

In order to detect lengths of strip in which the frequency of defect is high, the rate of defect occurrence method utilizes a preset integrating defect counter to identify the lengths and cause their address from the coil reference point to be recorded on paper tape. If desired, a second integrating counter preset to detect a lower rate may be included in the design which, in practice, would make available an area at the beginning and end of the defective length of strip in which slowdown could be initiated or otherwise permit the operator to determine the exact length of strip to be removed.

The characteristic difference between the continuous chart methods and those coil profile systems previously discussed is that the continuous chart methods in themselves do not provide a source of information with which a subsequent process can be programmed. This feature must be satisfied by an operator using as a basis for a decision his observation of the continuous chart record. Another limitation of the continuous chart methods is the high ratio of strip length increment to chart length increment necessary to facilitate handling the chart and the attendant problem of accurate speed synchronization between the strip and chart drives.

The nomenclature of analog input and digital spike input, assigned to the continuous chart methods, is self-explanatory for each type of record. It is suggested, since defect information may be analog and digital in nature, that it would be preferable to make the necessary analog to digital conversion so that a digital spike could be recorded on the chart for each defect foot. During the processing of a strip length having a high defect rate, the response of the pens would be such as to make a square wave record.

USE OF COMPUTERS

It is possible to use industrially designed digital counter computers for data accumulation. These perform the same functions as the straightforward system mentioned above, except with the functions performed through stored programs synthesizing the functions. The computer, of course, must be static to insure the reliability required of the system.

Computers are used presently in two cases. One, where the required functions are so numerous as to make the standard systems more expensive then a computer, and two, where a computer is used elsewhere on the line and excess capacity is available for data accumulation. The latter condition will occur quite often if a computer is used to close the information feed-back loop, as described previously, or is used as part of the servo and programming loops.

In closing, it is important to emphasize that the building of reliability into today's systems is of utmost importance since the techniques of data accumulation, as they are applied today, will form a firm foundation for future extensions of the basic systems such that many related steelmaking processes will be incorporated into a single large scale system.

Discussion

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R. M. Sills: We agree with the approach, suggested by the authors, of using a digital computer to reprogram

and optimize a system, rather than control it directly. We also agree that the need is for additional accurate process data, and that data accumulation and logging systems can be used to obtain this information. However, we would like to caution against the indiscriminate accumulation of data, or attempts to gather and use such data without careful prior analysis of the process. Unless it is known in advance exactly how the data to be collected will be used it is possible that it will serve no useful purpose.

We also agree that the future expansion of computer controlled processes does not today appear to be limited by computer technology. However, it is very likely that the lack of suitable sensing devices in many areas may cause some operators to delay their shift to computer controlled processes.

We disagree with the authors' views on the use of magnetic drums as storage devices. They state that these devices have not yet proved their merit in industrial type systems. Actually, we have several magnetic drums that have been in service for some time, and we know that other companies have had even longer successful experience with them.

It is certainly true that the trend in industry today is toward static devices. However, to rule out magnetic drums on this basis would not only be a disservice to the industry but in a sense would be to make a play on words. That is, while a rotating drum is obviously not static, the more usual connotation of the word "static" is the absence of mechanical contacts. Except for a standard induction motor driving a simple drum, the operation of a magnetic drum is all static and requires no contacts or conducting brushes. In this respect we feel it is far more reliable than most card readers or digital position feedback devices.

In a data accumulating system such as that described by the authors the magnetic drum has a number of distinct advantages. One of the most important of these is in the large reduction in the number of components required, with the proportional increase in reliability. In the equipments that we have built this amounts to something in the order of 50 per cent fewer transitors and other electronic components. This advantage should be weighed against any disadvantage there may be in using an induction motor. A magnetic drum installed in a tinning line data accumulator is shown in Figure 13.

As a shift register the magnetic drum is particularly attractive. For example, in one application it was necessary to provide a 400-ft delay. This would have required a tremendous amount of equipment by any other method.

The authors' system apparently does not allow a separate tabulation of all defects independently at the shear, and we presume for the reason that to do so would require a separate shift register for each defect sensor, which would require considerable equipment. With the magnetic drum system, this can be and normally is done.

One further point should be raised. We agree that it is not feasible to locate defects accurately enough to use such profile information for subsequently removing the defective section of strip without reinspection. If this is so, is there any value in recording profile information? Probably for some time to come the can companies are going to do their own inspecting and the steel companies are not going to want to give their customers profile information.

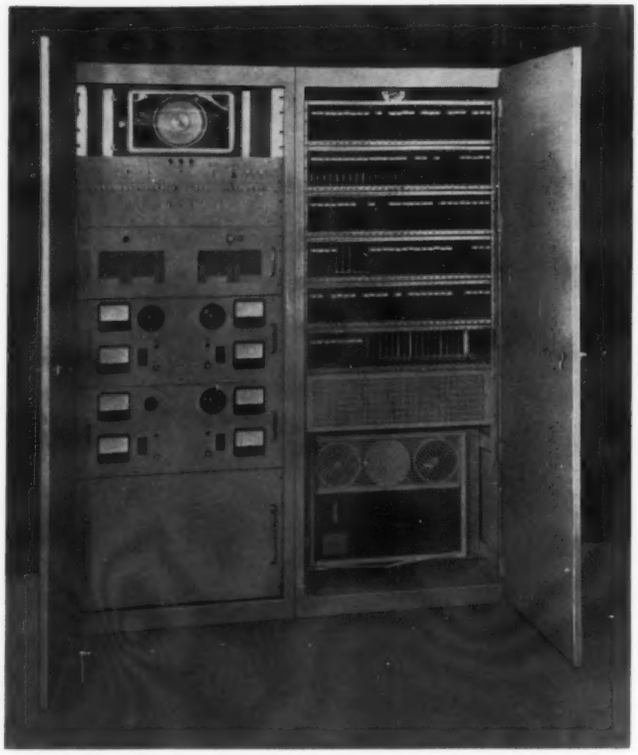

Figure 13 — Data summary is printed automatically for each coil of tinplate.

C. W. Ludvigsen: From our experience in developing and building data accumulation systems, we find that the accuracy and sometimes the reliability of the sensing devices used with data accumulation systems limit the results that might otherwise be obtained. Clearly the "state of the art" in building transducers and sensing devices is behind the "state of the art" in building the accumulation devices.

Under the section discussing the types of memory devices used in this application, the magnetostrictive storage device was not mentioned. We have found this device, which has no moving parts, no maintenance, unlimited life and no close tolerances, to be excellent for memory storage purposes. It is static, yet does not have a multiplicity of components that are proportional to the bits of storage, such as standard static counters. It has no bearings, no moving parts and no close tolerances such as are found in magnetic drums, yet it has the simplicity of the drum.

Reliability is very important in the data accumulation system. Far too many of the existing systems are lying idle because they cannot be made consistently reliable. Others require the full-time presence of an electrician to assure continuance of operation. Mention was made of the importance of the reliability when data processing becomes integrated with information feedback control and therefore becomes effectively an on-line system. Here, we agree, reliability becomes extremely important.

Our company offers both a single accumulator and a triple accumulator system. These systems are as fully reliable as anything on the market today. However, "on-line" systems and even in some "off-line" data

accumulation systems, downtime cannot be tolerated. Here we recommend the triple computer system. In a single system, if a gross breakdown of just one element occurs, the system stops operating. In the triple system, a gross breakdown of any one of the three computer circuits does not affect operation in any way. Repairs can be made hours or even days later and no data is lost at any time, even during the time that the repair is made. Furthermore, servicing is greatly simplified by having two properly operating circuits which can be used to compare waveforms against the circuit that is being serviced.

W. D. Rowe: In answer to Mr. Ludvigsen, we assume that the term magnetostrictive storage device refers to that type of storage commonly designated as acoustic memory in which the storage element consists of sound waves in mercury as used in the Univac I computer or nickel delay lines as used in the English designed computer Nicholas. If this assumption is correct, we agree that the device is static in construction; however, we would point out that it is dynamic in operation. This dynamic mode will dictate maintenance procedures requiring the use of an oscilloscope and specifically trained personnel. This belief is born out by Mr. Ludvigsen's statement to the effect that servicing of the triple accumulator system, as opposed to the single accumulator system, is greatly simplified by having two properly operating circuits which can be used to compare waveforms against the circuit that is being serviced. Field experience has shown that maintenance of our static system can be performed by relatively untrained maintenance personnel armed with nothing more than a voltmeter and a functional approach to the problem.

In regard to the triple accumulator system, we agree that there will be no loss of data, as would be the case in a single system, resulting from a fault in one of the three systems; however, it would seem if system redundancy was necessary in the first place, repair of the faulted system as soon as possible rather than days later would also be necessary to maintain the redundancy. Also, it would seem that three times the maintenance would be required for the triple accumulator system as for the single static system assuming equal reliability.

The root of Mr. Sills' strenuous disagreement in regard to our statement concerning the merit of magnetic drum storage devices applied in industrial systems lies in the definition of industrial type systems. We cannot agree that an industrial type system exists when a data accumulator or computer is applied in a steel mill if the accumulator or computer is enclosed in an air conditioned box. Certainly, the magnetic drum has its place in applications where large blocks of storage are required, an access time of 8 milliseconds (based on half a drum revolution at 60 rps) as compared to a few microseconds for electrostatic and magnetic core storage devices is acceptable and a suitable atmosphere is provided.

Contrary to Mr. Sills' presumption, our system permits the separate count and readout of each defect sensed. Only if a coil profile record is required would it be necessary to supply a shift register delay chain for each defect count.

Finally, we do not believe that the electrical equipment supplier can summarily decide on the merit of recording coil profile information. We must try to present the facts for what they are worth to the industry. However, we agree that present thinking is to question the worth of a coil profile record.

I. Rozian: Would you make a distinction between those variables that you would log or record on, say, a hot strip line for data accumulation versus those variables that you would record in order to plan a cross-loop control system?

W. D. Rowe: This, basically comes down to the point of view that on hot-strip lines at the present time we are not as familiar with the processes that are going on as we would like to be. Therefore, we would be attempting to measure and accumulate as much data about the line as we could using statistical methods, such as multiple correlation techniques. When you analyze the data and the system and possibly attempt to determine if equations exist or not, that might be helpful. We would probably try to look at some other things that we have not talked about; such as, strip temperature, if we had a good sensing device for it, probably strip width and strip thickness, and attempt to gather as much information as possible. Certainly, when you have hot steel, you cannot use your x-ray techniques too well, so our basic limitation is the sensing device.

I. Rozian: You mentioned that you record temperature and width. Is temperature and width the only thing you pick up in addition to motor loads?

W. D. Rowe: If it were a continuous strip line, we might look at tension, and also consider possibly looking at the strain on the mill housing and a number of other things.

The hardware used are little prepackaged transistor elements. They contain a single transistor and eight resistors. This particular device by itself can be built in large quantities with wide margins built in it. The little block called a NOR element is used over and over again by itself to perform all of the functions. Other than some capacitors, these are the only components used in the system as far as the digital operations are concerned. Having only one device which is static in which you can look at and determine what its condition is with a volt meter, makes it very easy to understand the operation and to check it. It also makes it fairly easy to design.

However, they do not smoke when they fail. Some present installations have in them automatic checking systems. The checking system, after each readout, automatically goes through and types out a matrix on typewriter paper. On this matrix all of the numbers that come out are the same. Should any one of them not be identical, you know you have an error, and you also know exactly which module it is that is giving you the trouble because of the functional arrangement.

We have three identical jobs. The first job when it was shipped was wire checked completely throughout the whole job; checking the wiring in all the modules. It took us about 150 hr to do this on the test floor.

On the second job that came through, instead of doing this, we checked to see that the power supplies were the right polarity and not shorted and then turned the power on and used the checking system to go through and see where failures existed. In doing this,

we reduced the check time down to 20 hour. It looks to me like the functional arrangement with automatic checking is an extremely powerful technique for both checkout and maintenance.

T. W. Lasiewicz: Where and how do you tie this equipment in with a computer after you develop your data and formula? Is this equipment then usable with the computer, or would you have to scrap it and put in a computer?

W. D. Rowe: There are two ways of doing it. If you are talking about our computer, the hardware is identical to the data accumulation system so single levels in operation would be very easily connected.

However, part of the equipment that we would have here would be desirable to use in the system. If we were designing a computer system from start we could get around it in the system making it a little less flexible. However, if we already had this system on and were adding a computer, there are some counters which we would no longer use. The referencing equipment, the scanning equipment, and read-out equipment would still be utilized.

J. L. Laidlaw: On a blooming and plate mill that we have which has your automation, the middle mill went in operation in February, 1959. The control was ready before that, but by the time it was ready to ship, it was out of date. Has your company considered renting this type of equipment to steelmakers so that we may have the benefit of all of the up-to-date equipment?

W. D. Rowe: The first time we applied this control was on the J&L reversing rougher mill, the first application of static control, as far as we know, to an in-line process of programming. We learned much and so did our customers. There is no question, however, that the operation did the job it was supposed to do. We went through two or three other mills using the information we had learned about this to further improve ourselves.

We built about three more, including one for Algoma, which used what was up to that time equipment thought as good as we could get. Since then we have come through with later equipment. We have taken all of the information and have a system using a functional approach which we now feel means that changes will not be imminent. We can still make improvements in details, but the functional arrangements of the systems and the interchangability of the system, as new things come along, will not change. What does this mean? If we can come up with a device that is faster or cheaper or more reliable, we can pull one of the old ones out and replace it with a new one and they will work interchangeably. It means that equipment that will be built now will not be obsolete if we find improvements in hardware, for we will not have a completely different system than before.

Now it is hard to say this after all of our past experience, but it has been a very serious problem for us that throughout this whole industry the changes and innovations are coming so fast that the customers cannot keep up with them. This is one of the basic things we have been looking for in our design. If we can find more reliable devices to put in it to make the system work longer without failures, all of our customers want to have these; yet, we do not want to make anything else obsolete if we can help it. We realize when we say we have a standard, this may be a point of departure, but what we have now will probably remain stable for a lot longer than anything else we have had.

Our feeling is that the next step in changing the equipment will be another type of concept. What we have now will probably be with use for at least two or three years without any major changes. We are in a situation now which will use mass production, and the same modules and the hardware are used in other places besides data accumulation. All of our new programming equipment is built the same way; our computers are built in this way; we have machine-tool control equipment that is being built using this equipment. We cannot afford to change it after we have put this much money into capital equipment to do it. We can make the minor changes to keep up, and the new improvements as they come. However, if our competitors force us what else can we do but change?

J. L. Laidlaw: So far as you know there has been no consideration given to leasing this equipment? Along these lines, for our locomotive radio, control over the plant, and trucks which have radio control, we carried that ourselves a long time. We replaced the radios and have had for three years a successful setup with the telephone company. We supply power to the units and that is all. They have mechanics or technicians who come in on call. They have a shop in the area. On a call, for example, trouble with a locomotive radio, they take the unit out and put another one in. We have talked among ourselves in Sault Ste. Marie about such a scheme of things on automation, at least for a number of years until the systems are established. We are not asking the manufacturer to do this free; we are asking for a system which would be suitable to you as far as money was concerned and to us so that we would get immediate benefit of all of the latest developments.

It is expensive equipment. To put it in the mill and find out in six months that you have developed new techniques and that what we have is very much out of date makes one wonder and is a question to be considered.

W. D. Rowe: There is a real pitfall in this which I have seen happen in the computer field, and that is, once you have equipment out that is rented, you are going to be very resistant to change in our own equipment because all you are doing is replacing your own equipment as a leasor. This might lead to retarding innovation of the things that you might really like to have.

G. J. Hay: Another thing to remember is that the steel producers themselves are expanding what they want to automate which out dates our equipment without any change of our own. For example, the latest mills are being installed with a program evaluator or computer. This is, as far as we know, an expansion that has been requested by the steel producers and is not a change resulting from our development program. This must be kept in mind when one talks about obsolescence of equipment.

W. D. Rowe: One thing more, the hardware we have here is more flexible by orders of magnitude than anything we have had. The hardware is adequate, if not the sensing devices. The understanding of our systems and how to control them is the thing that

really needs more work on it than the hardware that we actually have.

I. Rozian: What has your experience been on card preprogramming of the reversing mills, etc.? Do you feel that this is adequate, or do you need some kind of feedback for temperature and feedback for conditions where you do not get the right bite and slip?

W. D. Rowe: Presently we have eight mills operating.

G. J. Hay: This same question came up at an earlier meeting last week, and a comment was solicited from a representative of a Chicago area steel producer who has approximately one year's operating experience on one of our completely programmed mills.

His comment was that it was very difficult to determine what the operator was doing. He has small toggle switches on the desk beside him which are easily covered with his hand and it is difficult to determine whether he is jogging those switches. In other words, he has mill-operating experience. The program card goes through and as far as we know it is the programmed information, but not even the mill people themselves can tell whether he is jogging that information a little based on his experience. He may as an individual operator feel that he wants something a little different in his screw settings or manipulator position, but it is difficult to tell just what he is doing. It certainly is going to be different in the case of each individual operator. The operator has the responsibility of rolling the steel and he should have the manual override for psychological as well as practical reasons.

J. L. Laidlaw: We have had a similar experience. The rollers that we have on this new mill came from our existing 44-in. mill, and they do not agree often with what is put on these cards for the rolling technique. We have had several very heated discussions on temperature, etc., of an ingot or a slab coming from the furnace. It is settling down now, but for a number of months they did not agree with what was said on the automatic system.

W. D. Rowe: An interesting story about this happened several years ago. This was an automatic punch press which formerly had been operated by relays. To replace this thing with static control, we took an operator, explained to him how to work it, and from then on he could not produce a single piece of product correctly. They went over it and could not find a thing wrong with the system. Finally after putting a time study man on the problem, we arrived at the heart of the matter. He was operating this system originally and when relays—clicked in a certain manner—in a certain sequence, everything was all right; if they were not clicking right, he was overriding. He thought the relays ought to click in the right sequence and when they did not, he over-corrected, since the static system was silent. Addition of some inoperative relays produced sufficient sound to assure confidence in the operator.

I. Rozian: Working with a customer on one of these systems is a two-way exchange of information. What do you consider the most effective customer internal organization for working on the plans for such a system?

G. J. Hay: On the mills to which we have applied automatic program control, we have been very fortunate to have been able to work with an already established customer organization and engineering design group, and, as far as I know, they did not require any special qualifications. They worked with us very closely and we appreciated the way in which they accepted the new concepts that are brought out with this static device automation.

To answer your question specifically, we do not know that any of the customers that we have worked with on automatic programming have set up any special organization. This is in the engineering design stages and the same procedure is followed in the formulation of a maintenance program. There must, as we mentioned in the paper, be adequate means of checking the system inherent in the system itself. In addition, there must be instruction books from the manufacturer to the people who will be maintaining this equipment. We realize and accept that responsibility in that the steel producers cannot afford to hire a whole new group of people to maintain this equipment and that it must be done through the existing organization plus education.

W. D. Rowe: On most of our controls of this new type, we have been conducting schools with the customer. One school was pointed towards management to tell them what this mill can do, and probably more important what it cannot do, and then, secondly, there has been one which is aimed toward the maintenance personnel because the responsibility for the system operating and acceptance of the system really lies with them.

W. H. Collison: You have been talking mostly about processing lines and mills. It happens some of us come from the blast furnace and sintering plant. You mentioned a moment ago a school which would tell people what the plant should do, what the mill should do, and what it could not do. We have given thought to supplying more computers and controls to the sintering plant and the blast furnace. To what extent, do you think your data compiling and processing equipment would be necessary or desirable for a sintering plant and a blast furnace. Of course, the computers have not been applied yet, although there is one that will be applied pretty shortly in a sintering plant in Indiana Harbor.

W. D. Rowe: These are systems in which we are attempting to learn what kind of product we are getting and then what effects our controls have upon this product. If either of these two are the goals we are looking for, we would first attempt to collect all of the data that was pertinent. Now, we may not know what is pertinent, but we can determine this from a study of this data through a multiple correlation study, to see what are the important factors. Having done this, we can attempt to find out what effect changes on these important factors have upon my final products by the same techniques.

Now, if I were going to try to produce completely closed-loop feedback of information system on this, we would essentially want to run this correlation data all of the time. On this basis, we would then have a computer in the system which could make these calculations; since it would probably not use all of the capacity needed for this particular computation. We would also use some of the other capacity for data accumulation and possibly for programming.

J. L. Laidlaw: Could Mr. Collison elaborate a little

bit as to what he would expect to require from electronic data accumulating systems?

W. H. Collison: With pig iron, the scanning or sequencing of the product is probably not going to be helpful, particularly in the blast furnace, because some of the changes that need to be made need to be made eight hours ahead to keep control, and sequence the raw materials. In sensing raw materials in a sintering plant the control will operate or fail according to whether that sensing can be done properly. With a blast furnace, you would have to sense your raw materials. We do not think a punch-card system there would be at all applicable. The computer would probably have to change the furnace burden and furnace operating conditions, essentially blast temperature, perhaps moisture and blast, and items like that, almost continuously not when the product comes from the furnace but as those materials are entering the top of the furnace, which seems to be the only way that could be done.

A sintering plant is almost the same, although the lag is sometimes not a matter of eight hours, but roughly it takes a half hour to get material across the sintering strand. However you would have to be a half an hour ahead of certain conditions on the sintering machine, or something approximating that.

W. D. Rowe: We have some similar experience with an open-hearth which is somewhat the same problem in that you are trying to control input factors to get an operation to derive a product that occurs at a later time. The only thing that we can recall on that is that the programming that would be used would be a programming of the amounts of raw material being used. The various product that you wanted out would be programmed. You would finally get a result which, by metallurgical examination you could determine the quality. On the open-hearth with which we are familiar, they were attempting to make a particular product that they needed for orders. If they missed this product, they would keep records of what they did have, and also have a programming system which would optimize the programming of materials in their inventory of both raw materials and finished pieces to speed up the ordering. This is not the same thing you are talking about.

G. J. Hay: We have built program control for blast furnace charging but I have to emphasize that we do not know, and we think the industry will admit, that it lacks some information as to what the variables are. To the end of increasing the basic knowledge, we certainly will want to cooperate with the mill people to learn more about the process and what is to be done with this knowledge.

As an example, prior to our actual design work on the industry's first programmed reversing roughing mill, we went to the extent of taking movies of mill operating sequences. This was part of quite a lengthy study.

We have been awarded a contract to build a computer for a rolling mill. In connection with this contract, we have assigned quite a staff of men to study the variables and convert that information to computer intelligence. The customer is cooperating in this study.

T. W. Lasiewicz: U. S. Steel is going ahead on one blast furnace in the very near future with data accumulation with computer adaptability. They will work for about 210 items, some random data, some program data. The basic idea is like mixing a cake; they know if they put in so much of this material, and so much of that material, they hope they will come out with a good product. This is not always going to happen, but they will then in turn try to analyze what happens and try to correct the next batch.

W. H. Collison: I am skeptical about sensing devices. For instance, we were interested in an announcement of a sensing device that was going to control the bulk density in a coke plant. I should have said advertisement. When we inquired into that, it developed that it was a little premature. It was in the development stage, and not yet ready for use.

I have in mind a punch-card system. If you are going to accomplish what you want with a blast furnace, you will not use punch cards because before you get one of the things punched, your computer should be revising the data. If you have sensing devices, that will get all of the variations in your raw material to what extent would you use your data-collecting system?

One more thing, I think the computer people will have to learn a lot about blast furnaces and apparently blast furnace people will need to learn to know a lot about computers.

Dr. William Kiessel: On the blast furnace you talked about using a computer, for data logging; what complexity must a process have before you would use a computer for data logging?

W. D. Rowe: Look at it this way, the system as we have shown here is entirely a parallel system, every point on it is programmed. It is set up for the particular system we are talking about. We can get to every single point with a wire because it does one and only one function, and we can test it. As we add more functions to the system we have to add more hardware to do these functions. As this becomes larger and the system's cost goes up, it eventually reaches the same cost as you would have for the minimal size computer. Once you reach this point, what you must do is use the same computer equipment over and over again to do many functions in this one block. You do this through a stored program which can be flexibly changed. So our first thought would be when the price of the system which you need to perform all of the functions that you desire equals that of a computer and any extras that it needs to program it, then a computer would be adopted.

In the second place, where you already have a computer doing some other operations on the line and you do have spare people and spare time to operate on it, then there is no question but to use the available time on the computer.

How big a system do we get before this occurs? Each job has to be individually looked at to determine what you want.

On a couple of systems we are putting in, we are actually programming the gages and have all of the equipment in for this programming as well as the sensing of these things for both thickness and coating weight on tin lines. So, as you get up in your capacity, the biggest thing that will limit one is the amount of information that you wish to use; how many different bits of data do you want to store.

Dr. William Kiessel: You said that you are undertaking at the present time a study on a mill. What type of mill was this? Is this another tin mill?

G. J. Hay: A reversing plate mill.

Dr. William Kiessel: Is data being collected in this particular instance with a computer?

G. J. Hay: Yes. The data is being used to directly zero in on the product from the programming. Incidentally, this will be a flexible system. It will be designed to incorporate another mill and two levellers in the over-all system. Provision for the additions will be made in the initial design.

I. Rozian: To what extent have you been able to successfully use "analog" computers to simulate the overall control system dynamics?

W. D. Rowe: Wherever we possibly can, we do seriously make an attempt to do this. In fact, we are building a number of computers for particular jobs. We are building one of our own presently now to work with an "analog" computer we have, using the computer to attempt to simulate the system with the computer controlling it for our own studies.

Frank Koinis: There are about three factors in this computer problem: (1) is the design and application of the hardware which you and others have solved and is now no problem; (2) is the study of various processes and the means of applying the hardware to these processes; and (3) which has not been discussed but which is going to be a factor is the sociological effects of computer applications to industrial processes in general; that is, job elimination and personnel relocation, etc. Can anyone tell how that might affect computer development?

W. D. Rowe: A cliché often quoted is that in putting in such a mill we still need first of all people who are able to understand the basic operation of the automatic system. True, as systems become more and more complicated, our maintenance people are going to be trained. They are not going to be computer experts or electronics experts, but they are going to have to understand the new view. You will not be putting people out of jobs, but will be getting people of higher caliber and training. The real area of gain is increased productivity, not elimination necessarily of manpower. Consistency of product is part of this increased productivity.

Frank Koinis: We can see where that will follow on a new installation, but suppose we have a line that has a job history where there are a specific number of people working on it. We want to put in a new computer and in order to justify the investment, we cut the personnel down by 75 per cent; is that going to be possible?

I. Rozian: Maybe we can give a little bit of an answer to this. The population of the United States is doubling over 50 per cent nowadays. If you are going to increase your productivity to maintain your share of the consumer market, you are going to have to be able to turn out more and more tons every day. In these direct producing areas, it means if you hold your own with the computer, that you will hold your present level of manpower rather than expanding in the same proportions as the population as a whole. ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering, and so forth should be directed to that address.

1445 Shao, Hsiang-Hua: "Lamination Defects in Rimming Steel Slabs," *Acta Metallurgica Sinica*, 1959, Mar., pp. 16–21. (Author's abstract: An extraordinarily large gas pocket formed during the rolling of a rimming steel slag was studied. Results of investigation indicated that the serious lamination defects that often occurred in such slabs were due to the presence in large rimming steel ingots of central cavities that: (1) contained gases at high pressure, (2) were surrounded by heavily segrated metal and (3) were loaded at their surfaces with nonmetallic substances. During the rolling operation these cavities failed to weld up. On the contrary the solid walls dividing neighboring cavities were pushed open and as a result a large discontinuity remained in the rolled slab. It was found that after shearing the slab and thus exposing the discontinuity to atmosphere, in most cases such discontinuities could weld up during subsequent rolling into plates. Lower tapping temperature and lower pouring temperature (speed) were found effective to lessen lamination rejects.)

1452 Unterberger, M.: "Damage to Tooth Faces and the Load Capacity of Rolling Mill Gears," *Stahl u. Eisen*, 1959, Sept. 3, 1268–1272. (Author's summary: Instances of damage to various rolling mill drives. Pitting as a result of material fatigue through overloading. Case-hardened tooth faces for highly loaded rolling mill drives. Uneven load distribution diagram as a cause of local fatigue of the material. Load distribution factor takes into account uneven loading. Fracture resistance of teeth. Seizure damage to rolling mill drives. Lubricating oils with additives for short time application for burnishing tooth faces. Higher oil viscosity does not prevent the advance of pitting.)

1478 Funke, P. Sr. & P. Funke, Jr.: "Evaluating the Life of Cold Rolls," *Stahl u. Eisen*, 1959, Oct. 1, pp. 1412–1419. (Author's summary: Factors affecting the wear and life of a roll. An attempt to throw light on these problems by a continuous check on the condition of the roll. Suggested works control cards. Evaluating roll life over lengthly periods. Critical discussion and development of a method for assessing a cold roll.)

by R. E. LEIP, Coordinator Utilities Dispatching
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Profit Improvement Through Waste

. . . . the study of fuel requirements tied in with by-products availability will indicate areas for fuel and power savings . . . . with proper mill scheduling profits are increased and costs are reduced . . . .

THE by-product fuels of the blast furnace and coke plant are at times referred to as waste fuels. During the periods when the plant demand for fuel is below the volume of by-product fuels produced, the excess of these fuels is bled to atmosphere, and profit dollars are lost.

Fairless Works of United States Steel Corp. after seven years of operation is still rounding out its facilities, and in the process certain problems are created. One of these problems is the use of our by-product fuels; if they are used efficiently, profits can be improved.

The most important way to accomplish this objective is to schedule the operating mills in a pattern that would consume these fuels in the most economical manner. Such scheduling eliminates the very low demand, or by-product fuel bleed periods, and reduces the high demand periods which create operating problems; possible mill delay time, and higher product cost.

A survey of the utilities department shows that fuel costs are exceeded only by the cost of raw materials and labor. Since fuels are so widely used throughout the plant, a fertile field for affecting cost reductions exists.

This fact was highlighted during 1958 when Fairless Works intensified the search for ways of "tightening the belt." Since fuels and power are such a large portion of steel manufacturing costs, it was in this area that a closer look was taken. Btu's per hr were selected as

Figure 1 — Chart shows available fuels and base fuel requirements.

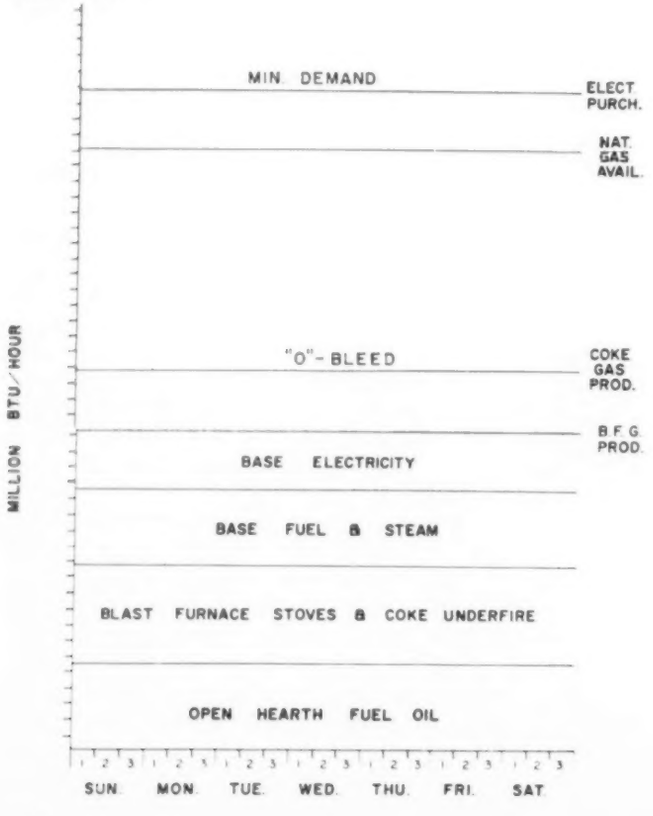
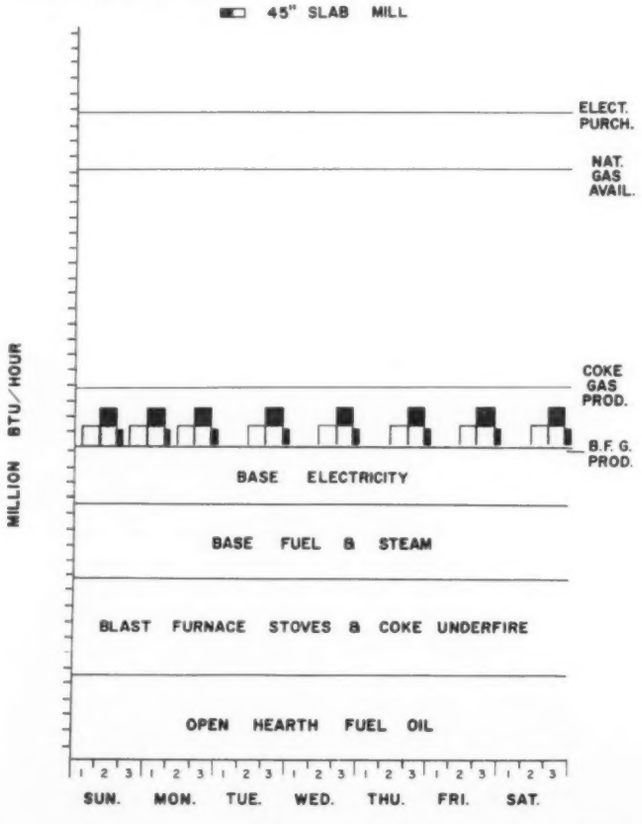


Figure 2 — By-product fuels can support 45-in. slabbing mill requirements.



Fuel Utilization

the common denominator, since both fuels and power could be expressed in these units.

To give a clearer picture of the approach taken, some of the charts prepared from a weekly operating schedule picked at random are shown in following figures.

Figure 1 shows available fuels and power converted to Btu's, plus the Btu's required to operate the base units of the plant. The base units are those requiring a continuous, or twenty-four hour per day operation, such as the blast furnace, coke plant, open hearth and such. Purchased fuels, oil and natural gas when available, are used in the open hearth during their heating and melting operations. Btu's of by-product gas production and requirements are shown above the open hearth. Approximately 30 per cent of the by-product gases produced by the blast furnace and coke plant are utilized in their respective operations. The remaining Btu's of blast furnace gas, and a portion of the coke oven gas production are used to supply fuel, steam and electricity for the remaining base units, such as the sinter plant, tin temper mill, batch annealing. Total Btu's required to operate these base facilities are approximately 48 percent of the sum of the by-product gases and the available natural gas and electric power at minimum contract demands. This then became the base operating line onto which all Btu requirements of the various mills are added. Btu's of coke gas production available to the rolling and finishing mills are shown above this base. The coke gas production level also represents the zero bleed point of by-product fuels. Plant operations entering the area above the zero bleed point, necessitate the purchase of natural gas, electricity or both.

Varied plant operations quite naturally increase or decrease the demand of base units on power and fuel, seasonal changes have practically the same effect. During the winter months much by-product fuel is used to produce heating steam, car thawing, etc. Therefore, savings in these operations will eventually put more dollars in the till.

After base Btu consumption was plotted, the fuel requirements of the various mills were calculated. In the succeeding figures the white areas illustrate the fuel used for warm-up and heating the steel throughout the rolling turn, and the black portion illustrates the amount of Btu's required to produce electricity. The mills were then plotted in the order of product flow through the plant.

Figure 2 shows the 45-in. slabbing mill, with the white area showing the warm-up time before the rolling period, and continuing for six hours of the turn. The black area shows that amount of fuel used to produce electricity and begins when the mill starts up. As can be seen, this entire operation has been

Figure 3 — Bloom and billet mill requirements have been added to those of the slabbing mill in this chart.

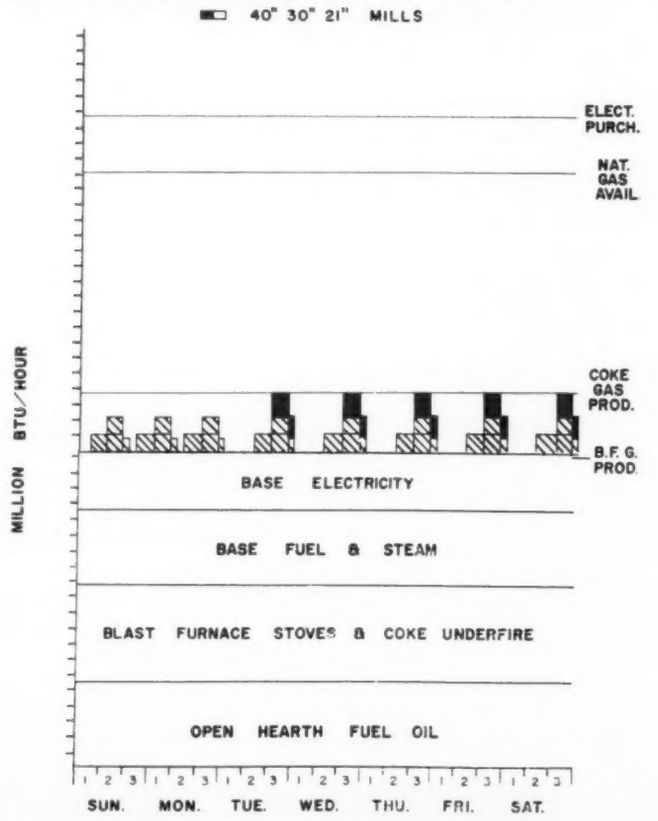
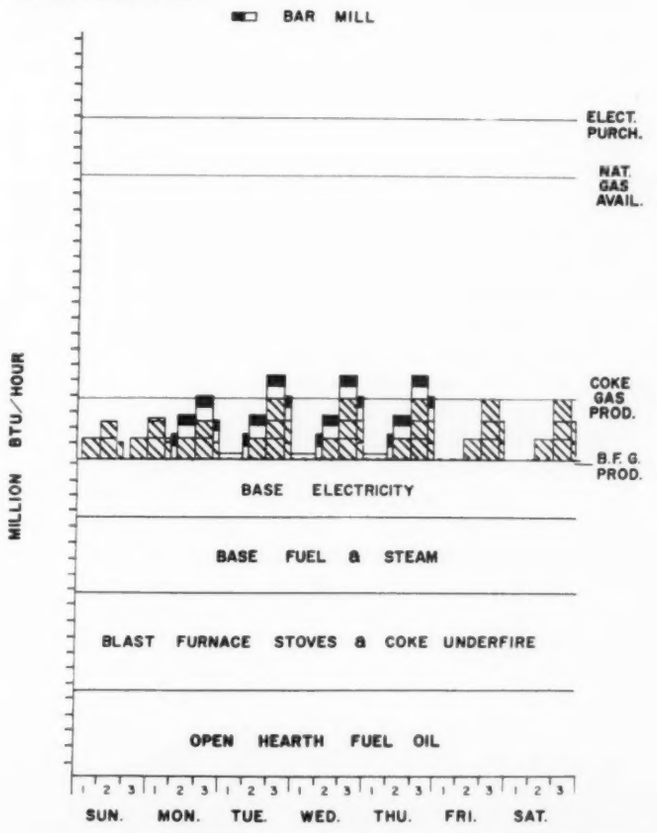


Figure 4—Addition of bar mill puts chart into the purchased fuel area.



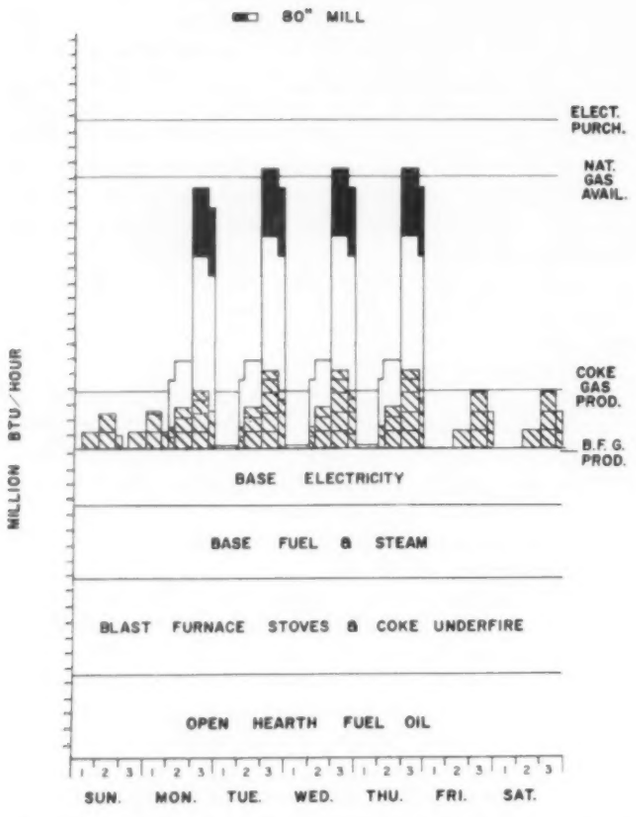


Figure 5 — The 80-in. hot strip mill is the largest power and fuel consumer.

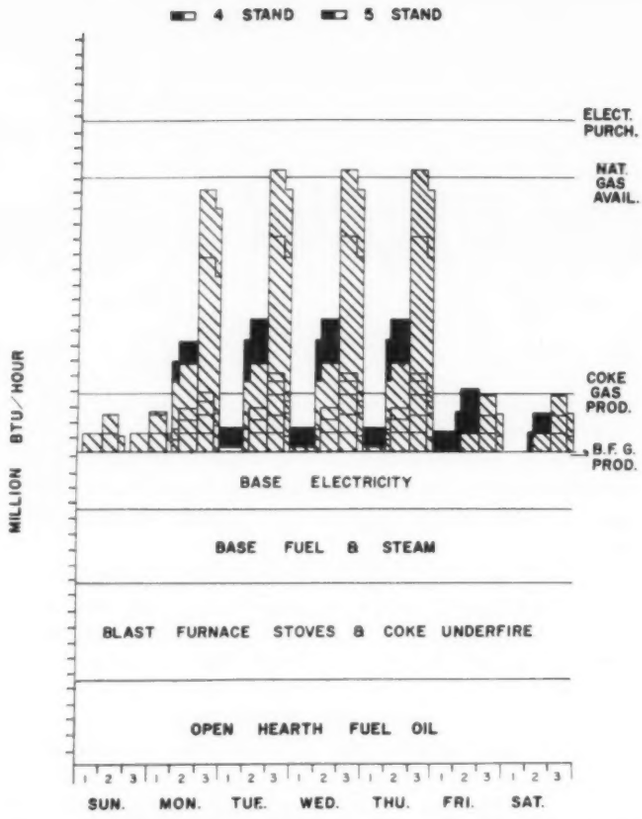


Figure 6 — Addition of 4 and 5-stand cold reduction mills increased both the use of by-product fuels and purchase of power.

supported on by-product fuels, and the no bleed point has not been reached.

Figure 3 shows the addition of the bloom and billet mills. Since the 45-in. mill supplies hot steel to these mills, the only fuel required is the amount needed to generate electricity. On five operating turns, the available by-product fuels have been utilized to the no bleed point, but on all other turns by-product fuel is still being bled.

In Figure 4 the bar mill is added; this mill has a reheat furnace and more of by-product fuel is being utilized. However, on several turns the Btu demand has entered into the purchased fuel area. On these turns where purchased fuel must be used, we are naturally going to use the most economical fuel available.

Figure 5 shows the addition of the 80-in. hot strip mill, which is the largest power and fuel consumer. This takes the graph through the area of natural gas availability and into the area where electricity is purchased. This graph points out another important and often overlooked fact. For years the utilities and operating personnel have talked about the electrical demand required for the 80-in. mill to roll steel, but what about the demand on fuel needed to heat steel to a rolling temperature? One can see that the Btu per hr of fuel needed for heating steel is far greater than the Btu's required to generate electricity for rolling. This definitely shows how much more important a good control on the use of heating fuels is in comparison to that fuel converted to electricity. This is another area for bringing about cost reduction—by improving reheat furnace efficiency.

Figure 6 shows the addition of the 4 and 5-stand cold reduction mills utilizes more of the by-product fuels, but has also forced additional Btu's to be purchased in the form of electricity.

To complete the picture Figure 7 shows the addition of the National Tube mills. This shows approximately 100 per cent utilization of by-product gases from Monday through Friday. Also notice on several turns, such high demand periods have been created that they are peaking beyond available gases and purchase power. This graph also shows that by-product fuels are still being bled on the weekend.

As mentioned before, mill scheduling is considered the prime means of utilizing our by-product fuels. Figure 8 shows the original schedule from which the Btu graph was drawn, and the proposed changes in the schedule which would help fill the bleed turns. The proposed changes in this schedule are those that are encircled, showing the mill and the turn or turns to be re-scheduled.

The bar mill originally scheduled to cover the second and third turns Monday through Thursday, was changed to cover the same turns but beginning on Sunday and continuing through Wednesday. The proposed change in schedule for the 5-stand cold reduction mill would have it operating on the first and second turns Sunday, Monday, Tuesday and Saturday, instead of Tuesday through Friday. National Tube weld mills were changed to operate on the first turn Monday through Friday instead of the third turn. The requested change in schedule of the National Tube weld mills was not proposed because of the elec-

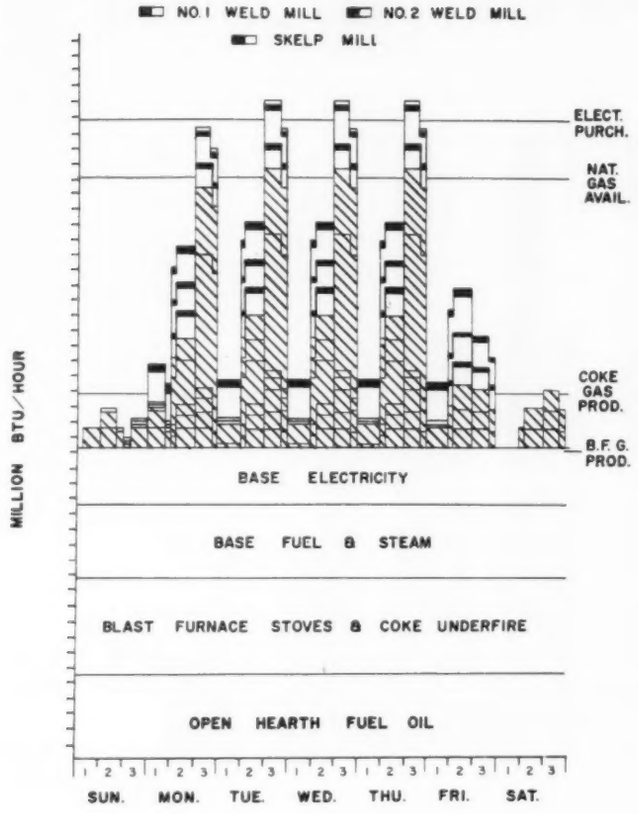


Figure 7 — The addition of National Tube mills utilizes practically all by-product gas.

trical power demand, as it was with the 5-stand cold reduction mill, but from a demand on fuel. Here again is the overlooked fact that the demand on fuel required to heat steel to rolling temperature for the weld mills, and also the skelp mill, is approximately five times greater than the fuel required to generate electricity to operate the mill.

The revised schedule at first glance may not seem to have any great effect; however, examination of the Btu graph drawn from the new schedule shows the magnitude of these changes.

In Figure 9, the by-product fuels bled, calculated before any change of schedule was made, shows a bleed of approximately 48 per cent of the total Btu's of by-product fuels available over the weekend. The revised schedule reduces the bleed of by-product fuel to 10 per cent of the total Btu's available, thereby showing a better utilization of 38 per cent of the Btu's bled over the original schedule. The white hatched area shows the turn coverage obtained from the revision made. These revisions to the schedule show a greater utilization of by-product fuels, and also reduce the high demand periods, black hatched area, to a point below our minimum electric power demand. Reducing the high demand periods brings about a savings in several ways:

1. It allows a better control and a more efficient operation of the mills.
2. Eliminates the extra demand charge imposed by the utility company when the contracted minimum demand is exceeded.
3. Eliminates mill delays incurred through slow

OPERATING SCHEDULE

DAY	SUN			MON			TUES			WED			THURS			FRI			SAT		
TURN	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
45" SLAB		X		X		X			X			X			X			X			X
40" & BILLET									X			X			X			X			X
80" HOT STRIP						X			X			X			X						
BAR MILL					X	X		X	X		X	X		⊗	⊗						
4 STAND					X			X			X			X			X			X	
5 STAND							X	X		X	X		⊗	⊗		⊗	⊗				
SKELP MILL				X	X		X	X		X	X		X	X		X	X				
NO.1 PIPE MILL					X	⊗		X	⊗		X	⊗		X	⊗		X	⊗			
NO.2 PIPE MILL					X	⊗		X	⊗		X	⊗		X	⊗		X	⊗			

Figure 8 — Operating schedule is revised to even out power demand.

REVISED - OPERATING SCHEDULE

45" SLAB		X		X		X			X			X			X			X			X
40 & BILLET									X			X			X			X			X
80" HOT STRIP						X			X			X			X						
BAR MILL		X	X		X	X		X	X		X	X									
4 STAND					X			X			X			X			X			X	
5 STAND	X	X		X	X		X	X											X	X	
SKELP MILL				X	X		X	X		X	X		X	X		X	X				
NO.1 PIPE MILL				X	X		X	X		X	X		X	X		X	X				
NO.2 PIPE MILL				X	X		X	X		X	X		X	X		X	X				

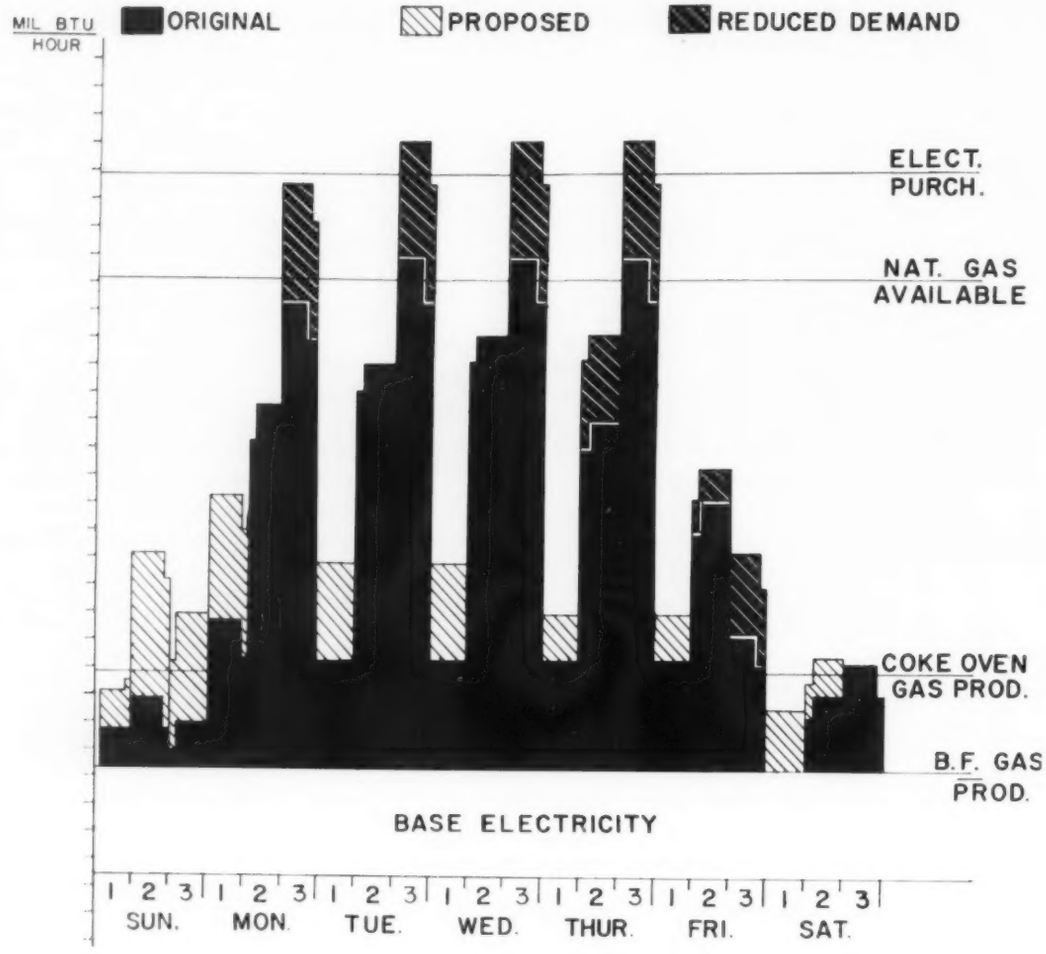


Figure 9 — Revised schedule reduces fuel wasted.

rolling or work stoppage attempting to stay within demand limits.

4. Eliminates the purchase of premium fuel at a much higher cost, which must be substituted to make up the additional volume of fuel needed for continued operations during the high demand periods.

The difference in the cost of fuels for an 8-hr turn operation may not seem to be of any consequence, but the difference in the cost of oil to replace 600,000 cu ft of natural gas is approximately $50 per hr. This amount of money by itself may seem small, but multiplied by many operating hours throughout the year becomes a large figure. In addition, many dollars are lost in the by-product fuels that are being bled away.

It was previously pointed out that in the operations of several mills, the demand on fuel for heating purposes was far greater than the demand for electricity. The same proportion holds true for the over-all operation of Fairless Works. The demand on fuel for generating steam, heating and processing of steel from the blast furnace to a finished product is approximately four times greater than the demand for electricity. This again merely serves to point out the fact that the heating fuel dollars have a far greater effect on the overall picture, and warrant a closer investigation for realizing cost savings.

Each week before the operating schedule is posted and becomes official, the utilities department confers with the production planning department and an effort is made to establish a schedule that will utilize by-product fuels to the fullest, and reduce the high demand periods to meet with minimum contracted limits.

Fairless Works is growing; new facilities are being added with an outlook to a better product and an increase in production. It might, therefore, seem reasonable to assume that our worries about utilizing our by-product fuels are at an end, but this is not quite true. As new facilities are added and production increases, the demand for hot metal and coke also increases. The increased production of these products places a greater volume of by-product fuels at our disposal, so the problem is still with us, along with many new ones.

In summation, the Btu graph and the information gained through its assembly and use, is a valuable aid in dispatching power and fuels as well as scheduling. After the schedule has been accepted, the utilities dispatcher draws the graph as shown. This assists him in ordering the required amount of fuel each day, and points out the low demand turns on which he would operate the powerhouse boilers completely on by-product fuels for better economy. It also highlights the periods when the demand limits on power and fuels will be reached, and close contact with the operating mills is necessary. In a few words, the Btu graph is an indispensable tool, and the proper scheduling of mills to utilize by-product fuels makes an ideal combination for increasing profits and reducing products costs to a competitive level. ▲

Increased mill speeds on a new mill usually give the operator many problems which he must solve and which are not present in the older, slower installations . . . . . the solution to these problems at Sheffield's new mill and a working agreement with the union, which eliminates others, are indicated in this paper.

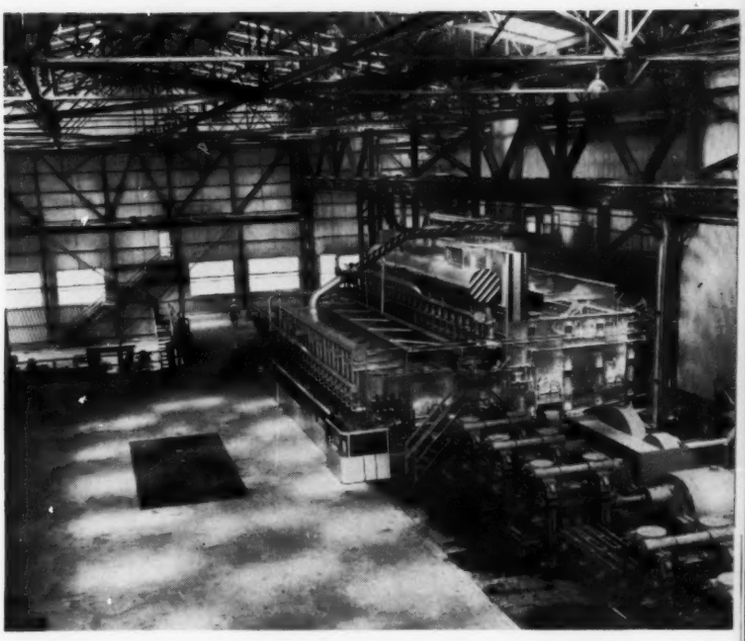


Figure 1 — Two-zone sloping hearth furnace has a rated capacity of 112 tons per hr.

The Operation of a Three-Strand High Speed Rod and Merchant Mill

by A. H. GRIFFITHS,
Superintendent of Rolling Mills, Sheffield Div., Armco Steel Corp., Kansas City, Mo.

IN 1953, when it became evident that additional rod mill capacity was needed at the Kansas City Works, two possible alternatives were considered. The first was a revamping of the No. 1 rod mill. The second was the installation of a completely new mill housed in a new building on adequate grounds. Studies of these considerations led to a proposal to construct the new No. 2 rod mill. After careful planning, contracts were let; and actual construction was begun on November 1, 1957. The 100,000 sq ft of building housing the mill rests on 1000 load bearing pilings driven to an average depth of 74 ft. It is a bi-level installation with the mill proper on the upper level 14 ft above the ground floor. This has minimized excavations, made it possible to construct gravity sewers, and permitted installation of piping in accessible tunnels under the mill. This building and its foundations required 14,000 cu yd of concrete. In its design and construction, every possible effort was made to incorporate the best of features from other high speed modern mills. This high quality of construction, coupled with careful supervision of details during the planning and designing period, has enabled us to start up with a very minimum of equipment difficulty.

PERSONNEL

During the 19 months while the mill was under construction, other activities, not connected directly with the building program but of equal importance, were in progress. Consideration had to be given to the selection of supervisors and to the transfer of crew members to staff the mill. It goes without saying that—without capable and willing manpower—a high speed rod mill can convert billets to cobbles at a very alarming rate of speed. Hence, personnel planning deserved a great deal of attention. The general foreman, the foreman and the rollers were selected from the best performers in other mills; and they were divorced from other duties and given an intensive familiarization program during the final weeks of mill construction. Industrial relations worked with mill supervision to develop a crew selection program which would minimize complications insofar as possible within the seniority setup. Meetings were held with the union and the following rules were established for staffing the new mill.

1. Only personnel from the 10-in. mill and the No. 1 rod mill are eligible for transfer.
2. The employee's rights to transfer to the new mill is based upon plant seniority rather than on seniority within either of the two mills.
3. Departmental seniority in the new mill will not be established until the third turn is staffed.
4. Employees going to the new mill have a 30-day period during which they can return to the old mill without losing seniority in their old department.

Figure 2 — Sheffield's modern 10-in. rod mill will roll a wide range of products.

5. Employees returning to the old mill after going to the new mill forfeit their plant seniority rights for later transfer to the new mill.

This agreement was very important. We had former crew members of the 16-in. rail mill and the plate mill who had stepped down from good jobs when these mills were deactivated to begin again at the bottom of the ladder in the 10-in. mill or the No. 1 rod mill. The plant seniority agreement has given these people an opportunity to restore their former standing; and—for the most part—they are loyal and willing employees. These and other crew members—125 in all—were individually interviewed to fill the 27 positions for the first crew.

After this crew was selected, there remained one additional task, the setting up of an equitable incentive plan for the new mill. Such a plan had to provide an opportunity for incentive earnings, yet it had to also allow for inexperience and initial difficulties on the mill. We definitely wanted to avoid the pitfalls of flat guarantees over extended periods. Industrial engineering and industrial relations worked on this and came up with an excellent plan which was subsequently agreed to by the union. The basic standards are established by design mill speeds and they contain allowances for normal delays caused by cobbles and by mechanical and electrical stoppages. These allowed delays are based upon the percentage of such time now recorded in similar well operating mills.

As an interim measure, there is a start-up compensation plan which included a three months guarantee of 125 per cent and a subsidy which is on a logarithmic curve. The rates are built up as earned hours; and the subsidy allows earned hours during the start-up period. For the first month, the allowance was 7.8 hr; for the last 0.6 hr. It is high in the beginning and drops off rapidly in the first four months. The subsidy curve is based upon the rate of production gain studied for other new mills, both within and without our own plant. Adjustments were made for the 116-day strike period; and, when the guarantee ended in January, 1960, the subsidy was given a boost equivalent to a two month backup to compensate for dropping the guarantee. The subsidy—by agreement—is finished at the end of 1960. By that time, the mill should be up to full production and the incentive can be applied without subsidy. Definite allowances for mill changes will be established later. The plan now allows average setup time of 1.08 hr per turn. This program is working out extremely well. During the first week of February, one turn averaged

246 tons per turn, the other 245 on No. 5 rod. The incentive earnings were approximately 140 per cent. In December, 1960, they will have to produce approximately 450 tons for the same earnings. It is firmly believed that the early industrial relations work in securing beneficial labor agreements and the subsequent incentive program prepared by industrial engineering have helped to establish good labor relations. This has complemented the excellent work of the supervisors to enable starting up with an outstanding manpower effort. We have operated approximately 180 turns to date and hope to hit a 400-ton turn very shortly. Looking back, this is a reasonable improvement over the first turn on June 10, 1959, when eight tons of saleable No. 5 rod were produced. So much for the history of the mill and its operations to date . . . we will turn now to the mill itself, and discuss its features and operations.

GENERAL DESCRIPTION

The mill proper is comprised of 23 closed top roll housings. These are of the parallelogram roll end adjustment type. Each is equipped with precision oil-flooded sleeve type roll neck bearings. Power is supplied by sixteen motors totaling 11,500 hp. Stands No. 1 and 2, 14 and 15, and 16 and 17 are driven in pairs through gear reducers. The six finishing stands, No. 18 through 23, are driven by two 1250-hp motors from both ends. The remainder of the stands have individual drives. Primary a-c power coming into the mill is converted to d-c by rectifiers. All main mill drive units are totally enclosed in steel fabricated, stress relieved housings. All gear rims and pinions are alloy steel forgings. All gears are jet sprayed. The bearings are pressure feed-lubricated. Five circulating oil systems containing 45,200 gal of oil are required to service the mill. Two hydraulic systems containing 1500 gal of fire resistant fluid control the roll balance, switch plate, traverse circuits and laying reels. For the three strand rolling of wire rods the mill is set up as follows:

16-in. roughing mill	Stands 1–4
14-in. roughing mill	Stands 5–9
12-in. intermediate mill	Stands 10–13
12-in. and 10-in. looping mill	Stands 14–17
10-in. finishing mill	Stands 18–23

Three 180 degree automatic repeaters located between stands No. 13 and 14, 15 and 16, and 17 and 18 repeat round sections for all rod sizes through $^{13}/_{32}$ in. Crop and cobble shears are located after No. 9 stand. The scrap from these shears is dropped into two crop boxes setting on narrow gage rail cars located in the tunnel under the mill. As soon as a car is filled, it is pulled out of the tunnel by a tractor and unloaded into a scrap car.

BILLETS AND FURNACE

Billets delivered to the mill are automatically unscrambled and fed into a side charge—side discharge furnace. This is a two-zone sloping hearth furnace, measuring 43 x 50 ft and having a rated capacity of 112 tons per hr. Gas is the main fuel; however, it is equipped to use oil when gas is not available.

Figure 3 — Motors of the Sheffield's No. 2 rod mill total 11,500 hp.

CONVEYOR

Coils are transported to the wire mill, 1760 ft away by a covered hook carrier. This carrier has 383 hooks located nine ft apart. These coils are removed at the No. 1 automatic unloader. Coils scheduled for removal at the rod mill are returned over this same distance, unloaded at No. 2 unloader in the mill and placed into rail cars for customer shipment. Coils are delivered from the reels to the hook carrier by a conveyor. Delay stations, installed between the reels and the coil conveyor increase loading efficiency and—in turn—reduce the speed of the coil conveyor and the hook carrier. This also permits the mill to be emptied of on-coming rods without the loss of product in cases of stoppages on the coil conveyor or the hook carrier.

PRODUCT RANGE

Initially this mill will roll high quality rods in sizes 0.218 through $^{7}/_{16}$ in. These are produced as 900 to 1000-lb bundles coiled into laying reels. There are six such reels. The mill will also roll rod sizes from $^{1}/_{2}$ through $1^{3}/_{8}$-in. into three pouring reels, starting May 15, 1960. The 1000-lb coil is obtained from a $2^{13}/_{16}$-in. billet, 40 ft long. The larger sizes are rolled into a 1700-lb coil obtained from a $3^{5}/_{8}$-in. billet of the same length. Flexibility of design will permit many additional operations. Room has been provided for a cooling bed so that this mill can be operated as a merchant mill. It could produce rounds, hexagons and squares in the range of $^{1}/_{2}$ to $1^{3}/_{8}$-in. equivalent round area; standard equal angles $1^{1}/_{4}$ x $1^{1}/_{4}$ x $^{1}/_{8}$ in. through $2^{1}/_{2}$ x $2^{1}/_{2}$ x $^{3}/_{8}$ in.; standard unequal angles from a minimum gage of $^{1}/_{8}$ in. through a maximum gage of $^{3}/_{8}$ in. to a combined leg length of 5 in.; and flats from $1^{1}/_{4}$ through $4^{1}/_{2}$ in. ranging in thickness from $^{1}/_{8}$ to $^{1}/_{2}$ in. It also has provisions for a skelp outlet to produce bevel edge skelp in width and thickness necessary for $^{1}/_{2}$ to 4 in. butt welded pipe. This would be a maximum skelp width of 16 in. for 4-in. pipe.

MILL PROBLEMS

Most new mills when trying to get started have ex-

perienced roll pass design and guide problems. The author is pleased to note that no major changes have been required thus far in either roll pass or guide design. So far, there have been a few other problems; however, we have been very successful in meeting these as they occur.

One of the problems was to prevent the loose front end of the coil from being trapped when the reel door closes and the sweep arm pushes the coil onto the conveyor. The mill electrical foreman corrected this serious problem with a type AM relay which automatically opens the door about 6 in. as the sweep arm pushes the coil onto the conveyor.

There has also been considerable trouble with pigtails. This is the formation of a hook on the end of the bar as the tail end rounds the repeater. In an attempt to correct this, a tail end slowdown device has been worked out by mill and electrical personnel. For the control of this device they are using photoelectric equipment located on the delivery side of stand No. 15. When the tail end of the bar passes under the photoelectric eye, an air cylinder exerts pressure on a drag shoe to slow the bar down. This cylinder and, consequently, the shoe pressure is controlled by a pressure regulator.

Thus far, there has been a minimum of roll problems. Rapid pass wear has been experienced with the high speed delivery of the finishing rolls; and other mills have this same problem. Experiments are being made with harder rolls. The present finishing train rolls are 72 to 75 Shore scleroscope. There are two sets of crush ground rolls for stands No. 22 and 23 scheduled for delivery during the week of April 11, 1960. These will be 85 to 87 Shore scleroscope; and it is hoped they will show improved results.

Another problem area is in the proper cooling of coils. Careful control is needed to insure proper adjustment for the water cooling of the rod between the finishing stand and the reels and for the air cooling of the rod in the reeling chamber. The metallurgical department has assumed the responsibility for these controls with the result that scale during coil formation has been reduced to less than 0.5 per cent for low carbon rods. Considerably more time is needed for them to work out standard practices to control physical properties and grain structure to the point where cold drawing can be performed without an initial patenting operation (particularly on rope and spring wire). Present tentative operating temperatures are given in Table I.

TABLE I
Tentative Operating Temperatures

	(Degrees F) High Carbon	Low Carbon	
From furnace	2060	2060	
Stand 1-2	1970	1960	
Stand 3-4	1920	1910	
Stand 9	1810	1790	
Stand 17	1820	1780	
Stand 23	1900	1850	
Entering reels	1525	1450	(Water-cooled)
Leaving reels	1500	1250	(Air-cooled)

The mill, like many other new mills requires time to reach expected tonnage. In the meantime, new developments must be made to combat problems. One problem is caused by the tail end of the bar being cold. Some modification has been made on the controls which initiates the crop cut on the shears to not only crop the front but also the tail end of the bar. A second problem is to reduce the number of cobbles caused by the premature throwing of the rod switch. The original electrical equipment operated as a rate function system which was sensitive to bar temperature variation. Rapid bar movement caused a change in light intensity. This sometimes triggered the switching mechanism. In the last week, the electrical people have felt confident that they have overcome this problem. This system is now being modified to a simple on-off photocell system and a signal generator to generate the necessary pulse voltage to initiate the operation of the equipment.

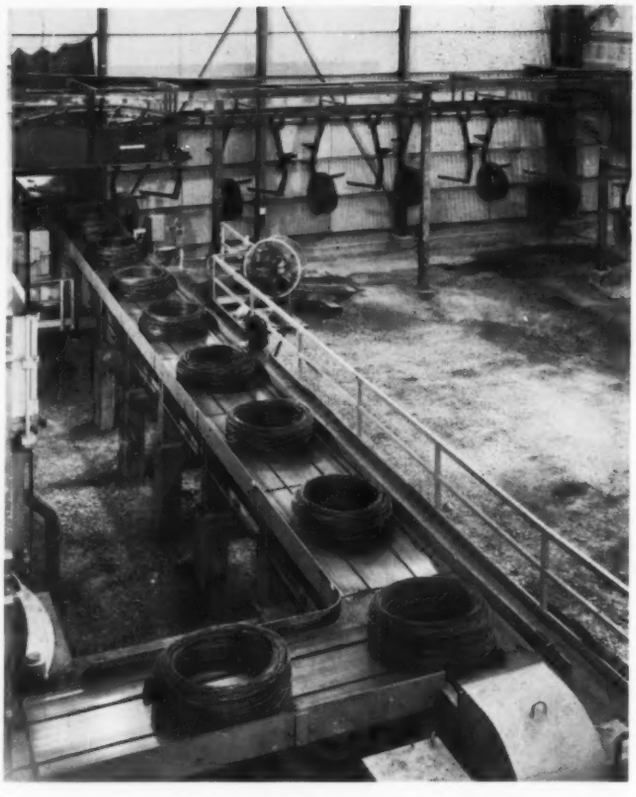


Figure 4 — Coils on mill conveyor are 1000-lb, of 0.218-in. wire. They are delivered by hook carrier to the wire mill 1760 ft away from the rod mill.

One of the outstanding features which prevents many problems is in the finishing train. Wherever the process oval is turned 90 degrees, water propelled roller twist delivery guides with simple twist adjustments are used. This type of guide directs the front end of the rod accurately into the receiving guide. It cuts down scratching and pickup; it reduces blocked passage cobbles; and it prolongs the life of the receiving guide. We consider it to be a vital part of any modern high speed rod mill. These guides are now operating satisfactorily at 6000-fpm delivery speed. We hope to have equally good results with the expected speeds of 6500 fpm.

SUMMARY

There are still many delays; however, improvements such as these just mentioned are continuing to bring time losses to a minimum. Maximum production should be developed within the near future.

Discussion

PRESENTED BY

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A. H. GRIFFITHS, Superintendent of Rolling Mills, Sheffield Div., Armco Steel Corp., Kansas City, Mo.

JOHN H. GREINER, Supervisory Engineer, Metals Industries, Industrial Systems Div., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

E. E. Brayshaw: It is interesting to note the emphasis Mr. Griffiths places upon the effect of personnel planning when starting up a new rod and bar mill. His comments on agreements with the union relative to staffing a new mill are most significant. Along this line, we at Keystone know full well the difficulties attendant to starting up a new type mill, particularly one on which the man power has had no previous experience, and where, when difficulties arise, the personnel, in their thinking, revert to the setup methods that have been used on an older mill. Without the careful planning noted by the author, he would have encountered many more difficulties than he has noted in his excellent paper.

The agreement was very important. At Keystone, there have been the manpower difficulties to which he refers. In a 14-month period, 112 men were put through 17 jobs. In this period some men worked on as many as 5 of the 17 different jobs. Further complicating the difficulties, not all the time worked during this 14-month period was spent on the same mill. There was a continual personnel movement between the old rod mill and the new rod and bar mill.

The author, with the help of the industrial engineering department and industrial relations department, evolved an equitable incentive plan, which is a real credit to him and the Sheffield organization. They are to be complimented upon handling so well this important phase of a mill startup. We have experienced the pitfalls of flat guarantees which run over extended periods of time.

The author spoke of having troubles with pigtails. This seems to be inherent with high-speed rolling on repeaters. We wonder if he has tried chains along the side of the repeater runout. We have found that by putting chains along the sides the slap of the bar is greatly cushioned. This tends to make the bar lie down, thus helping to prevent it from doubling back and folding over. We have been doing some experimenting with chains placed across the exit end of the repeater. In this position the chains seem to help to straighten the bar out, partially eliminating the tendency for it to double over. Would Mr. Griffiths comment on whether he feels there is a relationship between bar speed and the width of the repeater, which may aid or deter the formation of pigtails?

In talking with some gentlemen from Great Britain who visited our plant several weeks ago, we found that they too are using the roller twist guide in the finishing train of their rod mill, which is operating very successfully at speeds over 6400 fpm. These men feel that twister guides are essential to successful operation at high speed.

John H. Hitchcock: It is recognized by those who are informed that significant progress in the design and operation of rod mills inevitably brings new problems to the operators. Continuing advances make each new rod mill superior to its predecessors, in terms of larger bundle weight, higher delivery speed or closer control of size and quality, and these new features frequently give the operating personnel problems to deal with that they have not faced before.

One of the items of particular interest in this connection is the accelerated cooling of coiled product, which has had considerable attention in recent years, and will have much more attention in the early future.

A. H. Griffiths: We also are using chains to help eliminate pigtails and getting good results at speeds less than 5600 fpm. When rolling speeds at 5700 to 6200 fpm the holddown device has helped cut down pigtail cobbles.

We do not know whether there is a relation between bar speed and width of repeaters to cause the formation of pigtails. The No. 1 and 2 repeaters have 12-ft centers and No. 3 entering the finishing train has 13 ft-5 in. centers. All three are 6-groove repeaters and we have had pigtail trouble in all six grooves on high speed.

We appreciate the tribute Mr. Hitchcock paid to all the personnel involved in the design and construction of our new mill. Our hopes are to soon learn how to operate this mill to perform more efficiently.

John H. Greiner: The author in his conclusion spoke about attaining a 400-ton turn when rolling $^{21}/_{64}$-in. product. We would like to ask what the planned objective was, when designing the mill, in average tons per hr, when rolling a product mix from No. 5 rod to $^{7}/_{16}$ in.

We would also like to inquire about the success of rolling at 6500 fpm, assuming that by now this speed has been attained, or approached.

This interest in tonnage and speed stems from various reports on foreign competition. On structurals, plates and sheets the imports are down decidedly for various reasons. However, the imports on rods, wire and wire products are holding firm. One of the primary reasons is that this type of product need be offered only in a few standard sizes and specifications; consequently, large and costly inventories are not necessary.

In summary, it looks like the only way to overcome this competition is by price. High-speed, high-tonnage mills should help considerably.

A. H. Griffiths: The planned average tons per hour for 3-strand rolling at 75 per cent efficiency for five of the twelve sizes of finished rods from No. 5 rod and including $^{7}/_{16}$ in. are as follows:

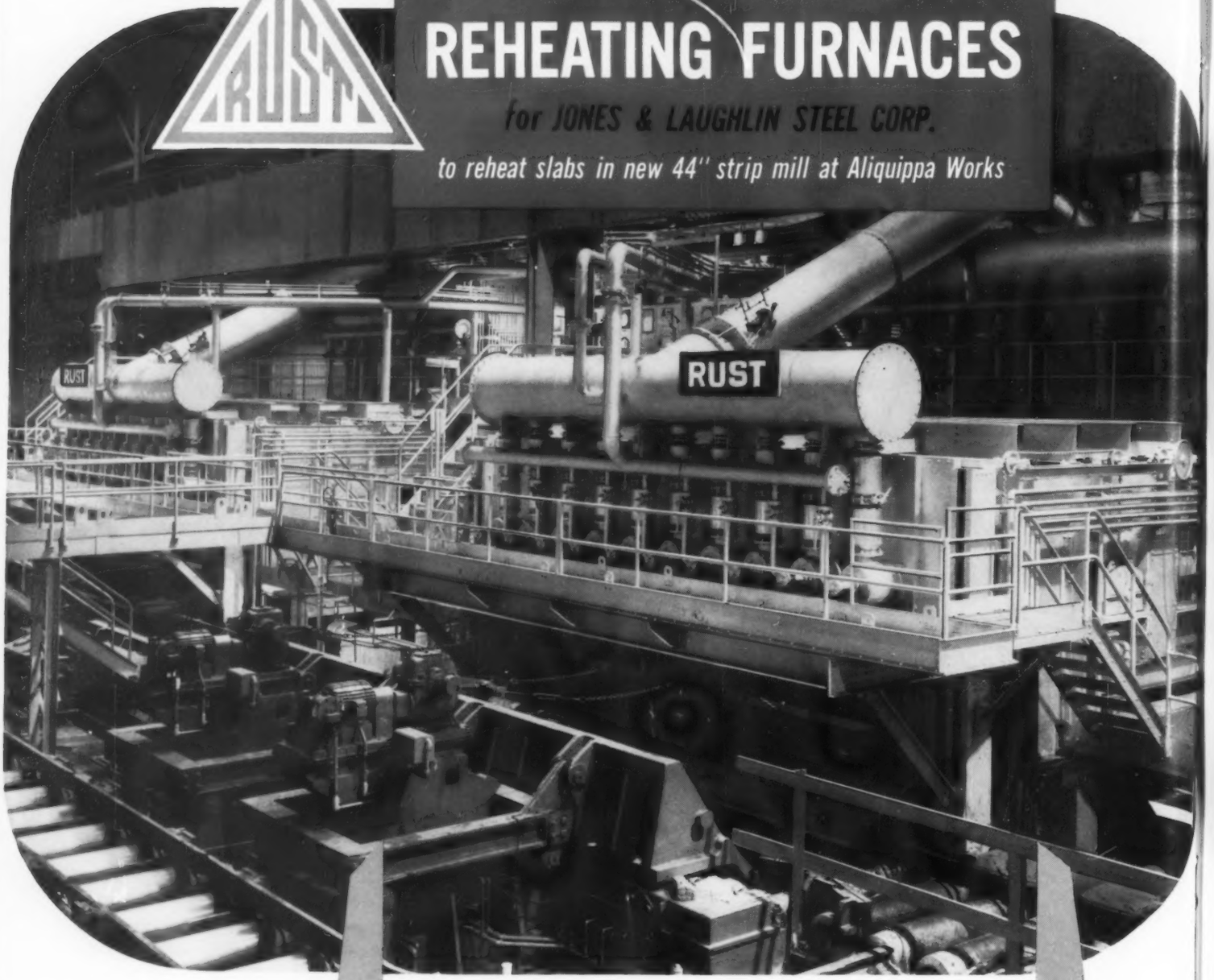
Rod size	Mill speed, fpm	Net tons per hr, 3-strand
No. 5	6000	46.4
$^{1}/_{4}$ in.	4430	49.9
$^{5}/_{16}$ in.	3265	57.5
$^{11}/_{32}$ in.	3255	69.5
$^{7}/_{16}$ in.	2390	82.5

We have rolled some tonnage at 6300 fpm but average speed is 5900 to 6000 fpm at this date. ▲

TRIPLE-FIRED CONTINUOUS REHEATING FURNACES

for JONES & LAUGHLIN STEEL CORP.

to reheat slabs in new 44" strip mill at Aliquippa Works



Two completely automatic gas-fired Rust furnaces, designed and constructed for the new 44" strip mill at J&L's Aliquippa Works. Each furnace heats cold slabs to rolling temperatures at a rate of approximately 150 tons per hour. Furnace temperatures range from 1650° F. at the entry end to about 2400° F. at the discharge end. The internal dimensions of the furnace are 26′ wide x 92′ long. There are 26 burners in each furnace, arranged in three zones. One set is at the discharge end, one set is above and one below the primary heating zone. Metallic recuperators help to boost capacity and minimize fuel consumption.

This zone-fired type of Rust furnace is used by virtually all strip mills throughout the world. Rust also builds all other types of metallurgical furnaces, designed for any fuel. Consult us about your requirements.

THE WHOLE JOB IS ONE JOB WITH A "RUST PACKAGE CONTRACT"

One contract covers everything from original idea through furnace start-up. One responsibility for design, manufacture, erection and initial operation. One overhead and profit (with substantial savings to you) on all phases of the work, including wiring and piping.

Rust Furnace Company

930 FORT DUQUESNE BOULEVARD, PITTSBURGH 22, PA.

Pioneers in Furnace Design

F 22

System Suppresses Incipient Explosions

ENGINEERS of Fenwal Inc., Ashland, Mass., a leading manufacturer of fire detection devices and temperature controls, recently demonstrated a unique, patented system said to offer active, rather than passive, protection against accidental explosions. This explosion protection system detects an explosion at the instant of its inception, and acts within a few thousandths of a second to snuff out the blast before it can become destructive. The system is said to be capable of dealing effectively with a vast majority of the ordinary explosion hazards known to exist throughout industry.

ENGLISH DEVELOPMENT

The system is based upon a British World War II development designed to prevent explosions in aircraft fuel tanks hit by incendiary shells. After the war, Graviner Manufacturing Co. Ltd. successfully adapted it for industrial use. Applications in England are estimated to have prevented losses of several millions of dollars since 1954, and no destructive explosions have occurred in protected equipment. In bringing the system to this country, Fenwal has obtained exclusive U. S. and Canadian manufacturing and sales rights for the system, established continuing technical collaborations with Graviner and independently designed and modified equipment to meet specific U. S. requirements.

SIGNIFICANCE

Nearly every process industry has an explosion hazard. Certain metallic dusts create an explosion problem in the metalworking industry.

The potential value of the protection system, which takes up where purely precautionary measures leave off, is shown by loss data compiled by the National Fire Protection Association.

It seems safe to assume that explosions caused about $100,000,000 damage in 1958.

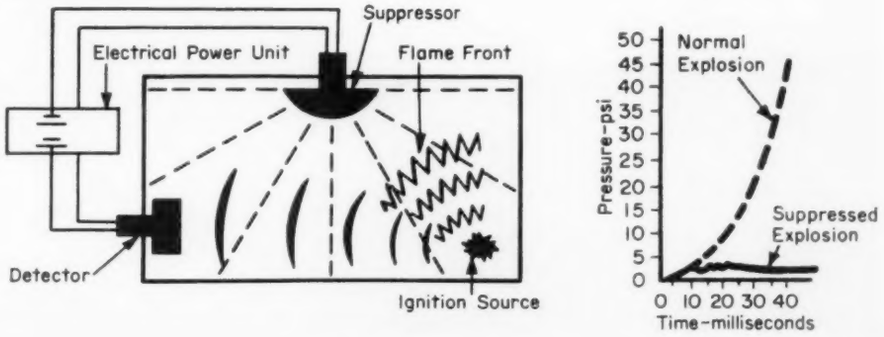
Nearly all current efforts to reduce these losses are passive, aimed at preventing explosions or controlling them, thus reducing but not eliminating loss. Most such systems depend upon fallible human factors.

HOW THE SYSTEM WORKS

System operation is based upon the fact that, although a blast appears instantaneous to the naked eye, there is a finite lapse in time between its ignition and the build-up of destructive pressures. The protection system acts within this period, which is measured in thousandths of a second. (The human eye cannot react to periods shorter than 0.1 sec.) In a few milliseconds the system detects the very beginning of the explosion, either by sensing the initial pressure build-up or the first tiny flash of flame, and automatically reacts to snuff it out. The blast is made harmless by a combination of actions, which may include any of the following:

1. Suppression — envelopment of the explosion with a suppressant.
2. Venting — opening a path to the atmosphere for controlled relief of pressure.
3. Advance inerting — introducing a suppressant into areas remote from the source of the explosion to prevent secondary explosions or fires.
4. Isolation — blocking the explosion from other areas.

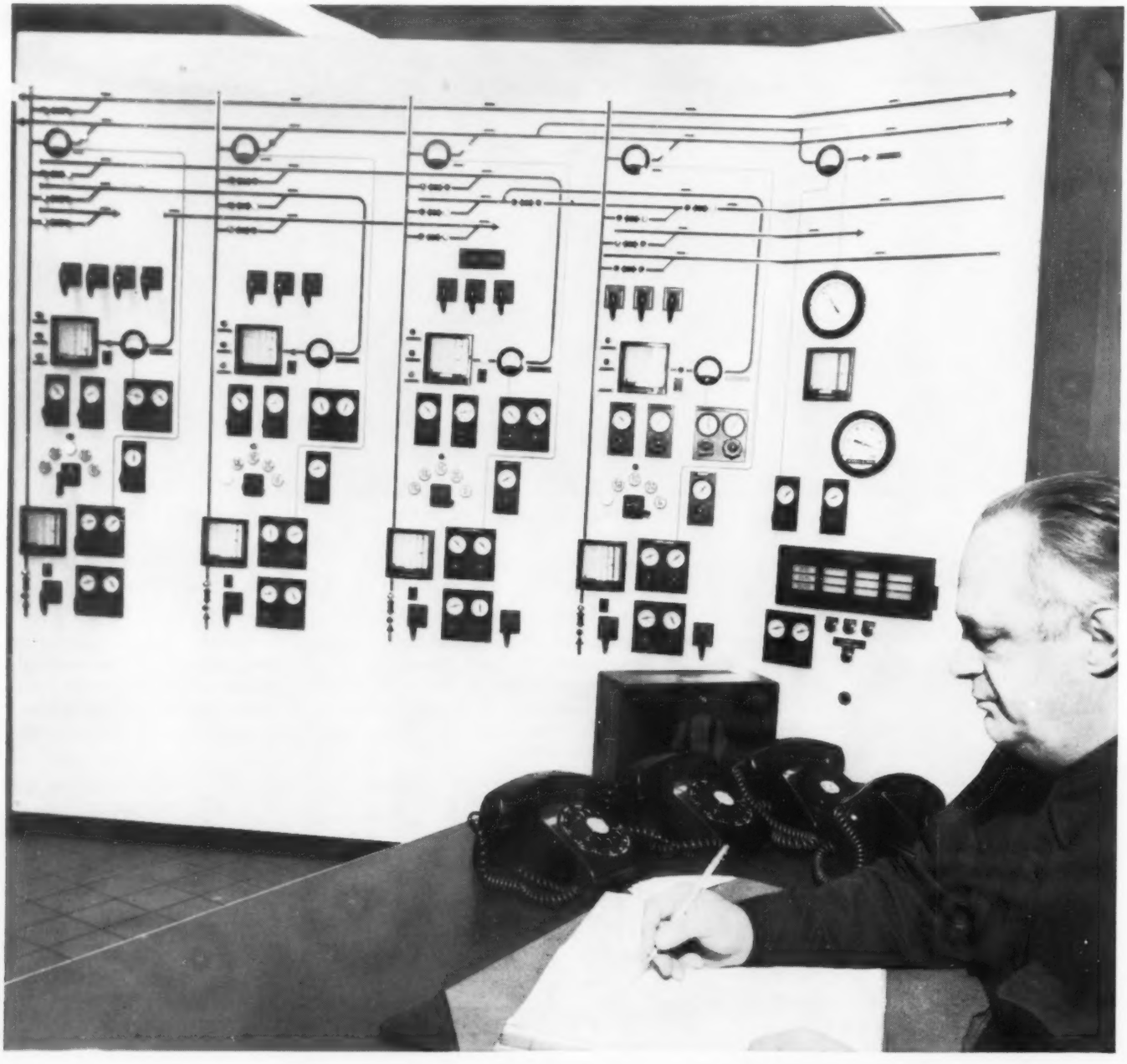
Figure 1 — Diagram illustrates the basic suppression system. The detector senses the incipient explosion and the suppressing agent is dispersed explosively. The agent extinguishes the explosion flame by chemical action and cooling, and also inerts the unburned explosive mixture. The graph shows the comparison between a normal explosion curve and a suppressed one. Note the low pressures attained in a suppression.

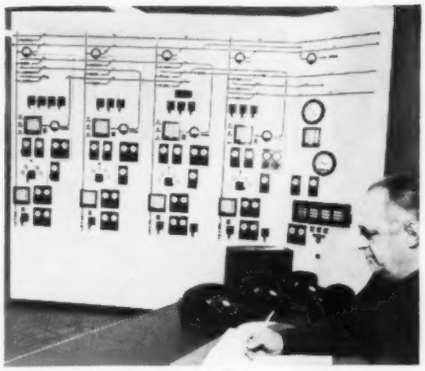


At U.S. Steel's Gary Works . . .

LOWER BLAST FURNACE BLOWING COSTS WITH HAGAN SPLIT-WIND CONTROL

Designed for future expansion, the graphic control panel is programmed in this manner: ■ No. 4 Turbo is blowing Furnace No. 11. Its excess capacity is "spilling-over" to augment the wind from No. 2 Turbo. ■ No. 2 Turbo is blowing Furnace Nos. 9 and 12, with the additional wind from the "spill-header." ■ No. 6 Turbo is blowing No. 10 Furnace.





Today, split-wind blowing makes it possible for existing turbo-blower capacity to meet the constantly increasing wind requirements of rebuilt, enlarged blast furnaces and to do this at maximum possible efficiency.

A control system, to accomplish this objective, must provide centralized control for operator economy, and the flexibility needed to achieve high blowing efficiencies regardless of varying flow and pressure requirements.

In the system shown, installed at the Gary Works of U.S. Steel, three blowers supply blast air to four furnaces, with a fourth blower on operating standby. Normally, one turbo blows the furnace requiring the highest blast pressure. Excess wind passes into a spill-header and is used to augment the wind from the other active blowers.

The graphic control panel makes true centralized control possible by performing the following functions: shows the position of all control and shut-off valves—indicates and records the flow and pressure to each furnace—shows configuration of manifolding to blow the furnaces—provides communications between the control room and the cast house floor—records and indicates flow and pressure of each blower—provides remote manual operation of the shut-off valves—gives operators a means of changing furnace flow set point and manifold pressure.

For more information, write for Bulletin "Hagan Blast Furnace Control Systems."

HAGAN

CHEMICALS & CONTROLS, INC.

HAGAN DIVISIONS: CALGON CO.
HALL LABORATORIES • BRUNER CORP.

5. Automatic plant or equipment shutdowns.

Figure 1 shows the basic suppression system and a graphical comparison of pressure build-up vs time of a normal blast, and one which has been automatically suppressed.

Since 1956, Fenwal has been testing the system at a secluded test site near Framingham, Mass. The test center is believed to be the only one of its kind in the United States. Work there has been performed under both Fenwal and private company sponsorship.

Primary research objective has been to investigate the explosion characteristics of various explosive materials. The important conditions of practical explosion problems, such as temperature and pressure and volume are duplicated in special explosion chambers. High-speed electronic instruments record such information as temperature and pressure build-up with reference to time, of both uninhibited and suppressed blasts.

Sequential still photographs taken from high-speed motion picture studies of actual explosions at the test center, give graphic evidence of suppression effectiveness.

SYSTEM COMPONENTS

Each explosion protection installation is unique, because it is tailored to meet the specific needs of the protected process or equipment. However, every installation consists of a combination of standard components. Systems can also be designed to protect against fire and explosion hazards by combination with standard extinguishing methods. Such combined systems usually provide considerable savings over separate systems.

Heart of the system is the explosion detector. Either a pressure or radiation device, the detector senses the incipient explosion and, in conjunction with a power unit, generates an electrical signal. Pressure detectors are sensitive to either the rate-of-pressure-rise or to a specific static pressure, or to both. A signal occurs when the pressure rise from the incipient blast exceeds either setting, indicating an explosive condition. Radiation detectors are designed to selectively sense certain wave lengths of the spectrum which exist in an explosive flame but to reject others present in natural or artificial light, thus eliminating potential false alarms.

Upon receipt of a signal from a detector, the power unit, which is equipped with stand-by batteries for safeguard against power failure, delivers electrical energy to operate the various explosion protection devices in the system.

Protection devices may consist of suppressors, isolation valves or vents. All are operated by explosive detonators, similar to the precision electric blasting caps used in seismic exploration, for rapid actuation. It should be noted that the vents are not merely rupture disks blown out by the explosion itself but are opened before destructive explosion pressures occur. The time lapse between ignition of an incipient explosion and the operation of the various explosion protection devices is just a few thousandths of a second.

Suppressors may be easily ruptured hemispherical containers or high-rate discharge bottles. Both contain liquid suppressants. When activated, they dispense the liquid in fine particles moving at speeds up to 600 fps. The incipient explosion is cooled by heat of evaporation of the enveloping suppressant mist inhibiting further combustion. The most common suppressants used are water and bromochloromethane. As an example of the quantities of suppressants required, only 5 cc of water or 2 cc of bromochloromethane can suppress an incipient explosion in a one gal volume.

Essentially the vents are special glass windows which are fractured by an explosive detonator mounted against their outer face. Operation of the detonator fractures the glass, but the elevated pressure of the incipient explosion within insures that fragments will fly outwards, away from the protected space and process.

There are two types of swiftly acting isolation valves, butterfly and flap. They are held open, against heavy spring pressure, by a hollow metal link. Operation of an explosive detonator within the link breaks it, allowing the spring to slam the valve closed and hold it there.

A combination of protection devices is desirable to protect most processes. ▲

DAVY-UNITED

AUTOMATIC GAUGE CONTROL

OPERATING IN CANADA

56-inch 4-High Cold Reversing Mill at Dominion Foundries and Steel Limited, Hamilton, Ontario, which is equipped with the Davy-United system of Automatic Gauge Control. This mill rolls steel strip for tin plate between 24 inches and 50 inches wide in a range of thicknesses from .006 inches to .050 inches.

Six Automatic Gauge Control installations have now been completed or ordered in North America and Licensees in North America for the Davy-United system of Automatic Gauge Control include General Electric Company of the U.S.A., Canadian General Electric Company Limited and Canadian Westinghouse Limited.

AGC by DAVY-UNITED

DAVY AND UNITED INSTRUMENTS LIMITED, DARNALL WORKS, SHEFFIELD, ENGLAND

379/DV

Electric Arc Heater Develops Very High Temperatures

A MACHINE with the potential capability to supply a stream of gas at temperatures as high as 20,000 F and pressures as great as 15,000 psi has been devised by the Westinghouse Electric Corp. The machine, an electric arc heater, can operate for sustained periods of time and at an extremely low level of gas contamination.

The arc heater has immediate application in a wind tunnel for missile testing. Also, it holds promise as a chemical synthesizer and as a furnace for processing metals with ultrahigh melting points. A prototype model of the machine has been operated at a power input of 1700 kw, but a high of 30,000 kw is planned by the company.

The temperature into the nozzle has been maintained at 10,000 F. In addition, flow from the nozzle of the unit has reached a sonic velocity of 3400 mphr. Velocities over ten times the speed of sound can be expected when the gases are expanded with a hypersonic exhaust nozzle.

The unit's potentialities as a furnace might make a number of refractory metals available in ingot form for the first time. Normally used in powder form, metals such as tungsten are difficult to process because of their high melting points.

In all of these applications, the success of the arc heater is greatly dependent upon a low level of contamination. One of the problems involved in units under development during the past two years is that electrodes and walls of the chamber burn and thus contribute impurities amounting to as much as 10 per cent of the mass of the gas flowing through the system.

The Westinghouse unit has a guaranteed maximum contamination level of 0.2 per cent. Still further reductions in this level are contemplated.

In addition, it is believed that the Westinghouse arc heater has a uniform temperature profile within the heat chamber. In other words, the temperature at the entrance to the nozzle is constant.

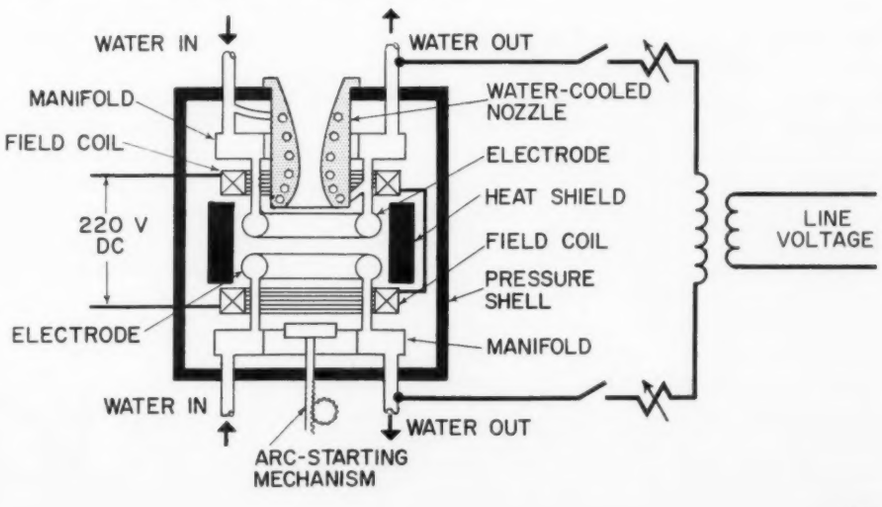
The basic concept for the new arc heater is a scheme in which an electric arc, dissipating megawatts of electric power, can be maintained for prolonged periods of time to continuously transfer thermal energy to a gas passing through the arc. This is done virtually without erosion of the electrodes, thus all but eliminating this cause of gas contamination.

A key to the performance of the new machine lies in the design of the two electrodes which form the terminals for the arc. Each of these electrodes consists of a hollow doughnut-shaped ring placed horizontally, one directly above the other. Water is pumped through the hollow rings for cooling.

An electric arc is started by drawing it across the gap between the two rings, and then rotated around the gap at a high rate of speed.

Rotation of the arc is accomplished by a magnetic field from d-c coils arranged around the outside of the heat chamber. This rotation,

Figure 1 — Arc heater schematic cutaway.



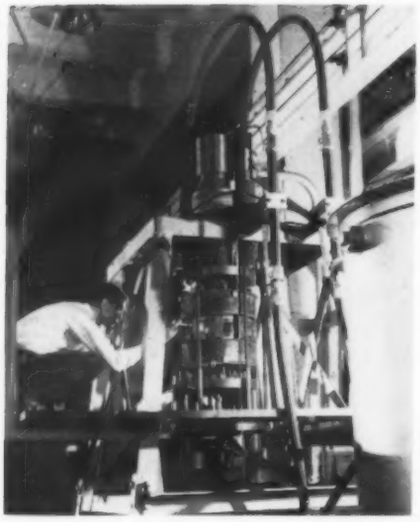


Figure 2 — Temperatures can be developed as hot as those on the surface of the sun.

combined with water-cooling, prevents the electrodes from heating to a point beyond the structural endurance of the material. Repeated tests of the unit have left the electrodes undamaged, indicating a lack of contamination from this source.

The working fluid, such as air or nitrogen, enters the arc chamber and passes into the arc through openings near a water-cooled copper heat shield. The water-cooled heat shield, which can withstand arc temperatures well above 10,000 F without eroding, protects the walls of the arc chamber. After leaving the arc, the fluid passes through a water-cooled nozzle.

The prototype arc heater was designed to accommodate a 1.2-lb-per-sec flow of either air or nitrogen. The unit should be able to supply gas at 1500 psi with a constant enthalpy of more than 2000 Btu per pound for as long as 10 min without damage or measurable gas contamination. The efficiency of heat transfer to the gas is in excess of 50 per cent.

So far, the highest pressure at which tests have been conducted is 730 psi. Other tests with a power input of 549 volts and 5046 amp (9450 kw per lb per sec) have raised the enthalpy of air passing through the chamber 4670 Btu per lb. Equipment of this type can use either direct or alternating current, single or three phase.

Main components of the equipment are an arc chamber and a power supply. The arc chamber consists of a heavy steel envelope in which are housed the electrodes, the magnetic arc-rotator coil, a nozzle and a variety of auxiliary mechanisms. The power supply for an alternating-current system includes reactors, transformers, switchgear and control circuitry. A d-c system which uses a rectifier can also be supplied.

Depending on facility power requirements, an arc heater with its power supply may cost from $500,000 to $1,500,000. ▲

Crane Collector System Combines Copper With Carbon

RINGSDORFF Carbon Corp., has introduced a new current conductor system for cranes, and other electrified machines, to the American market, with all components manufactured in the United States. This system, is proved in the field for a period of over 40 years on the European continent.

The system utilizes carbon sliding contacts on its copper head steel conductor rails. This method was adapted because:

1. An excellent conductor, copper, is used in conjunction with carbon contacts.
2. The wear of the copper conductor is negligible—under normal conditions its life will be several decades due to lubricating effect of the carbon.
3. The wear of the carbon contacts is practically nil.

The current conductor system is made up of three major components, namely, copper head steel rails as conductors; pantographs with carbon shoes as collectors; and special high strength Steatite insulators.

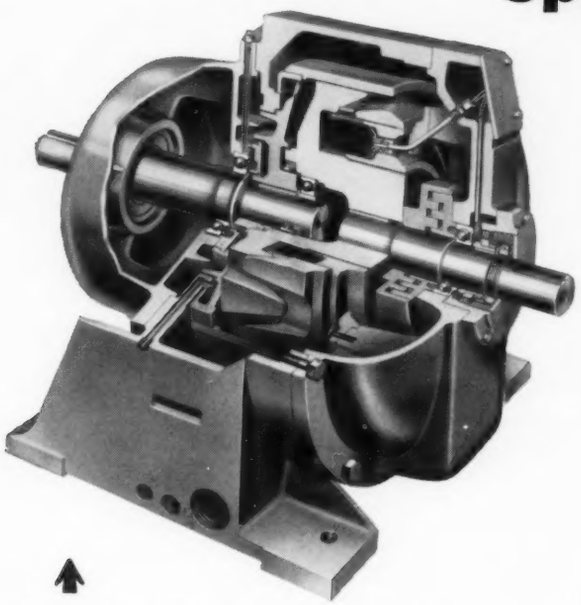
The use of copper head conductor rails with carbon as a contact means that there is no possibility of corrosion of the rail contact surface and in addition the graphite deposit left by the carbon sliding piece gives the copper a protective coating plus a certain cleaning effect. The crane current collectors, pantographs, with their scissors construction propelled by springs are far superior to the ordinary rigid contacts.

The pantograph allows for misalinement while keeping contact on the rail. This flexibility is a distinct advantage and the pantographs can be designed to take up any amount of play. The insulators are made of a refractory material called Steatite which is electrically the equivalent of porcelain but stronger structurally. Cement has been eliminated in fastening the bolt to the Steatite—instead a slit bushing conically expanded within the insulator is welded to the bolt.

The entire current conductor system is relatively small and lightweight; therefore requires no strong supports. Because of the usually very limited space for crane contact lines, the current collectors have been designed as small as possible and the joints of the scissors (twin guide construction) have been arranged in such a way, that the contact is kept at a nearly constant pressure in all positions and is directed perpendicularly to the contact lines. The collectors may be positioned vertically in an underrunning or over-running position in respect to the rail or in a horizontal or sideways manner. These current collectors are for use with cranes of all sizes; electro pulley blocks, and suspended railways.

One of the most recent applications of the current conducting system is in the new 629-ft ore bridge built by American Bridge for the National Tube Div. of U. S. Steel Corp. at the Lorain Works. ▲

The BEST Solution to Difficult Speed Control Problems—



Dynamatic Liquid-Cooled Couplings provide infinitely adjustable speeds for nearly every application from 3 to 75 HP. Note the absence of slip rings, brushes, and commutators. Heavy-duty types with capacities up to 5,000 HP are also available.

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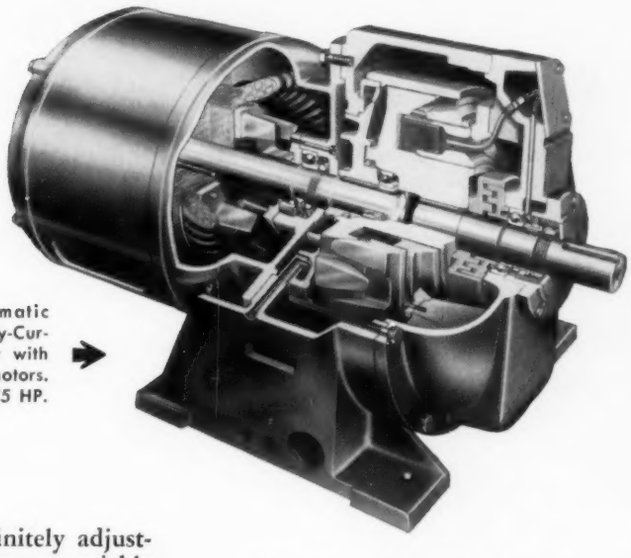
LIQUID-COOLED EDDY-CURRENT COUPLINGS and DRIVES



"Dynaspede" Drives are Dynamatic Liquid-Cooled, Stationary-Field Eddy-Current Couplings mounted integrally with standard, D-flange, squirrel cage motors. Available in capacities from 3 to 75 HP.

Here's Why—

Dynamatic Liquid-Cooled Couplings and Drives provide infinitely adjustable speed from a constant speed source—or constant speed from a variable speed source. They operate on standard alternating current. Rotary power is transmitted through the coupling by an electromagnetic reaction between the driving and driven members of the unit—there is no mechanical contact of rotating members to cause wear and require adjustment or replacement.

A wide range of standard and special control features may be obtained from a remotely-mounted electronic control system. Infinite speed adjustment, constant speed control, on-off clutch control, torque limit, acceleration control, inching, and threading are a few of the many functions available. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Liquid-Cooled Dynamatic Couplings and Drives deliver more horsepower than other types of the same physical size, thus conserving space in a busy machine area. Efficient heat dissipation permits continued operation at low speeds, or stall with full load.

Completely enclosed, Dynamatic liquid-cooled units are protected from dust, dirt, and other atmospheric impurities. Dynamatic design involves no brushes or slip rings; there is no possibility of arcing. With simple modification these units can be made explosion-resistant for hazardous applications.

Infinitely Adjustable Speeds from AC Power

★

Full-Torque Starts

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Wide Range of Control Functions

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No Slip Rings, Brushes or Commutators

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Completely Enclosed Design

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Low-Cost Maintenance

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DYNAMATIC DIVISION

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Large Pipe Mill Put in Operation At Calgary, Canada

ONE of the largest continuous pipe mills in the world is now operative in Ogden, Calgary, Canada. The Big Inch Pipe Corp., Ltd. mill was specially designed to manufacture large diameter high strength transmission line pipe for oil, gas and water. The plant is capable of producing pipe from 18 to 36-in. outside diameter, with a wall thickness of $\frac{3}{16}$ to $\frac{5}{8}$ in.

In the operation, 60-ft lengths of steel plate are trimmed to required width, then moved by crane and fed into the forming mill, which operates on a continuous basis to bring the formed open seam to the welding head, where by means of high frequency electric resistance it is forge-welded, then scarfed inside and out, sized and delivered to the run-off table.

The automation and continuous welding operation is made possible by the use of the patented thermatool high frequency resistance welder, which introduces 400,000 cps current directly into the metal by means of two small sliding contacts which ride one on each side of the open seam. Current at this frequency has different characteristics than the commonly used low frequency current employed in standard resistance welding. At this high frequency the current follows the path of low inductance, rather than the low resistance path.

The open seam of the pipe is kept in an elongated "V" form as it nears the welding head, and the two sliding contacts riding a few inches from the root of the "V" introduce the high frequency current directly into the metal. The current from one contact flows down one side of the "V" to the root and back along the other edge of the open seam to the other contact. Each contact acts as a return for the other. With the utilization of high frequency current the heat affected zone is small, in fact probably the least of any welding process, since only the edges of the open seam are heated to welding temperature, and very little heat is dissipated into the body of the adjacent metal.

This high frequency resistance welder manufactured by the New Rochelle Thermatool Corp. has many advantages. In association with this mill it makes possible production speeds of from 25 to 75 fpm. In the case of $\frac{1}{2}$ in. wall pipe, the speed will exceed 35 fpm, with a possible speed of 50 fpm.

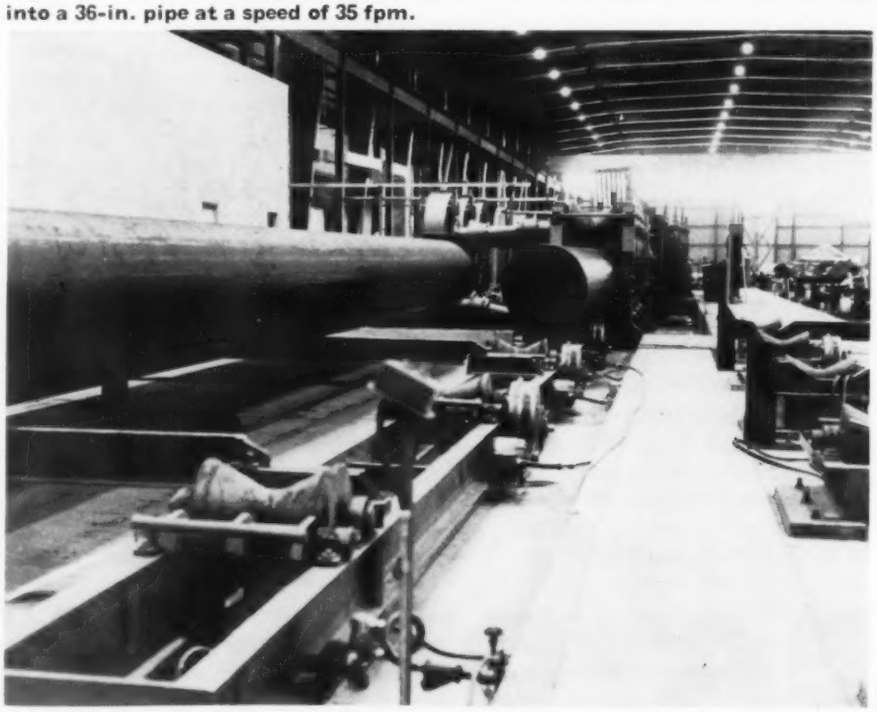
Another feature of this process is that hot rolled steel does not have to be sand blasted or pickled to remove the scale and oxidation. This effects sizable savings. No flux or other metal is used in connection with the welding operation, an additional saving. The forged weld resulting from this type of welding has proved stronger than the basic metal under the most severe tests, and has uniform hardness. The method of pipe manufacture has been approved by the American Petroleum Institute.

The flash and splatter in high frequency resistance welding is negligible, eliminating a costly cleaning operation. The bead formed by the upset during welding is comparatively small and scarfing is easily accomplished. Another feature made possible by high frequency resistance welding is the fact that this mill can be operated by five or six men as compared to the eighteen or more men needed by conventional mills.

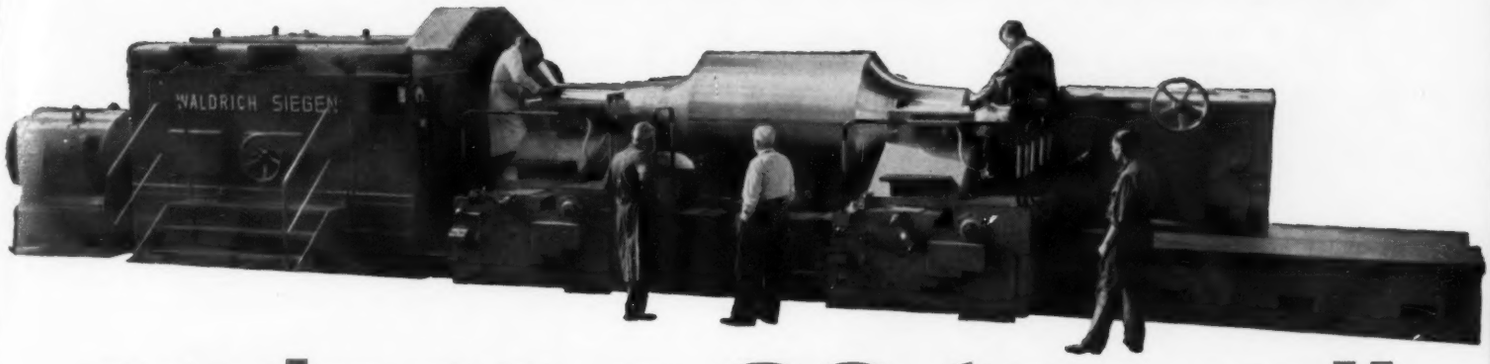
An interesting feature of this installation is the 280-kw generator, believed to be the largest high frequency generator for industrial use that has ever been built.

The entire plant which is 600-ft long cost over $4,500,000. The Cal Metal Corp. of California built the mill which was engineered for use with the Thermatool welder. ▲

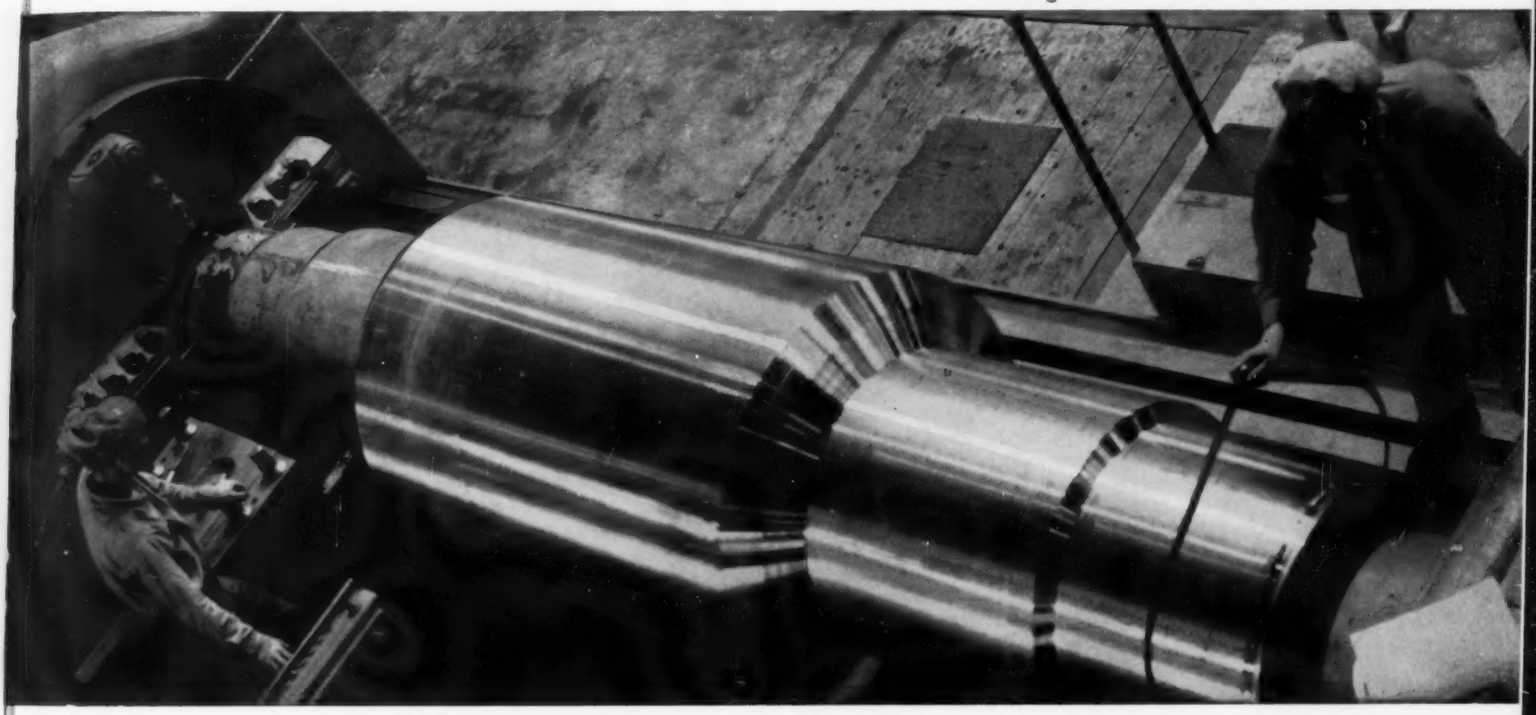
Figure 1 — The 64-ft length of steel, ½-in. thick, has been formed and welded into a 36-in. pipe at a speed of 35 fpm.



this Waldrich giant



swings a 90-ton roll



—cuts rough turning time 75%

You're looking at the business end of a Waldrich-Siegen Roll Turning Lathe, built to turn a workpiece as long as 30 ft., as fat as 63 in. in diameter, and as heavy as 90 tons!

Right now, you're seeing it in action at the Ohio Steel Foundry Co., Lima, Ohio, biting into a 57-ton, 98-in. long roll, with a 53-in. O.D. In just three passes, its hungry cutters will shear 15 inches of steel off this diameter. Before it's through, 12 tons of turnings will come off.

This job used to take 68 hours at Ohio Steel Foundry. The husky Waldrich breezes through it in just 16½ hours flat.

It takes plenty of muscle to peel through so much steel and the Waldrich has it, delivering 250 horsepower to the spindle. Speed is set at the selector wheel, feed at each of the two independent carriages.

And here's an interesting economy note: chips from the Waldrich lathe are large enough to be remelted, unlike finer chips from other lathes that oxidize too quickly. Ohio Steel Foundry collects a bonus of $15 on every ton salvaged.

Three different size Waldrich lathes are now in operation at this plant, turning workpieces with maximum O.D.'s of 36″, 48″ and 63″. Maybe one of these sizes is the answer to your roll turning needs. It's easy to find out. Write today for complete details on these heavy producers.

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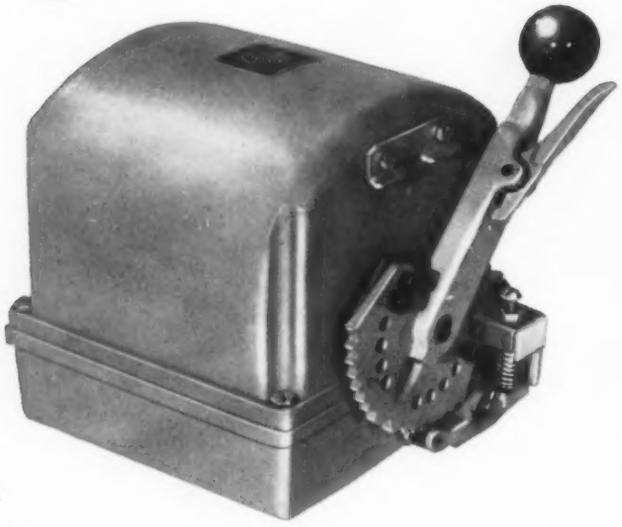
MILL-DUTY ACCESSORIES



MASTER SWITCHES

Heavy-duty design offers long life, high reliability

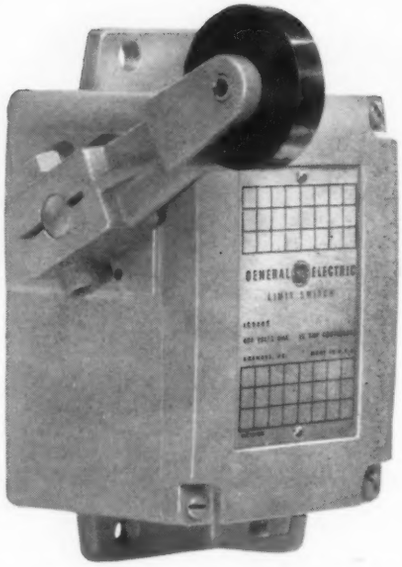
Self-lubricating phenolic cams—impregnated with graphite—keep General Electric master switches performing longer . . . even in the toughest conditions. Numerous mill installations show that these cams—coupled with steel cam followers—will operate millions of times without replacement.

Modern design of the G-E master switch permits quick modification—with a minimum of parts—to perform different sequences. And, cams can be interchanged without disassembling the switch. Offered in surface- or desk-mounted models, these switches are 25% smaller than other designs.

Check these "extra-value" features of General Electric master switches:

- **Entire switch unit** lifts out of enclosure for ease of wiring and mounting.
- **Pawl arrangement** allows for convenient adjustment to each operator's "feel."
- **Adjustable stops** give maximum of seven points in each direction, plus off.

Want more information? See your G-E Sales Engineer; or write Sect. 784-28, General Electric Co., Schenectady, N. Y. for Bulletin GEA-6706. *Industry Control Dept., Salem, Va.*



LEVER LIMIT SWITCHES

New adjustable cams permit fast, on-the-job adaptation

Here is a new lever-operated limit switch that lets you adapt it to the application . . . right on the job. You no longer need to predetermine circuit requirements before selecting a device. This means fast installation or quick adaptation when requirements change. A new system of adjustable cams on General Electric's lever limit switch makes this flexibility possible. A template—provided with every switch—guides changing the cams.

Lighter and more compact, General Electric limit switches are available for either two- or four-circuit operation . . . and, in a wide choice of enclosures.

Consider these key features of the new General Electric lever limit switch:

- **Readily-accessible contact blocks** are of unit construction, easy to wire.
- **Variety of levers** offers wide selection to meet your specific application.
- **Starwheel** may be set for either maintained or spring-return operation.

For the complete story, see your General Electric Apparatus Sales Engineer, or write Section 784-28, Schenectady, N. Y. for Bulletin GEA-7203. *Industry Control Dept., Salem, Virginia.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

Remote Control Used On Plutonium Rolling Mill

AN important step in the taming of plutonium for peaceful use was accomplished with the completion of the world's first rolling mill designed to operate entirely by remote control within an airtight steel enclosure vessel. The mill was designed and built by Loma Machine Manufacturing Co., Inc., of New York for the Hanford Works in Washington which General Electric Co. operates as prime contractor for the U. S. Atomic Energy Commission.

The machine constitutes the major rolling facility serving the plutonium recycle test reactor and will be used to produce fuel elements in a variety of shapes and configurations. The "PRTR" project is a long-range experimental program expected to lead to the use of plutonium as a fuel for nuclear reactors. The first fuel loading for the reactor will comprise 85 elements, of which 25 will contain plutonium fuel in the form of plutonium-aluminum alloys while the remaining 60 elements will contain uranium dioxide.

Although plutonium is not among the most radioactive materials, it is an alpha-emitter of high toxicity and therefore has to be handled with extreme care. The alpha particle has a relatively low penetration ability and can be stopped by a comparatively thin shield, such as the rubber gloves employed in glovebox enclosures. The greatest danger at a laboratory or processing plant handling plutonium is the inhalation of plutonium-bearing dust. Plutonium entering the body is deposited primarily in the bones and is excreted very slowly; the time required for man to excrete one-half his body burden is estimated to be about 100 years. According to current knowledge, the maximum permissible total body burden has been set at 0.5 microgram, and plant ventilation requirements are such that the air must not show a plutonium dust content greater than 7×10^5 micrograms per cu meter of air.

Since plutonium readily oxidizes in air and there is a danger from spontaneous combustion, it is necessary to process the metal in an inert atmosphere of argon. Hence, unlike a conventional rolling mill, the new machine has been designed for complete enclosure within a fabricated steel hood or glovebox. The four sections of the hood will be flanged on to the mill housings in cruciform shape, with two sections containing the run-in and run-out tables, as well as an electric resistance furnace, and the other two sections containing the mill drive spindles and the roll removal and storage ways. The entire hood virtually is a large vacuum vessel which will be evacuated to a pressure of 1 micron Hg prior to the start of operation. It is then backfilled to atmospheric pressure with argon in order to obtain an atmosphere of acceptable purity. Rubber gloves techniques will be used in operating the mill, with the gloves being attached to the hood by means of glove rings or ports. The extreme reach of these gloves is about 24 in. and their working distance about 18 in.

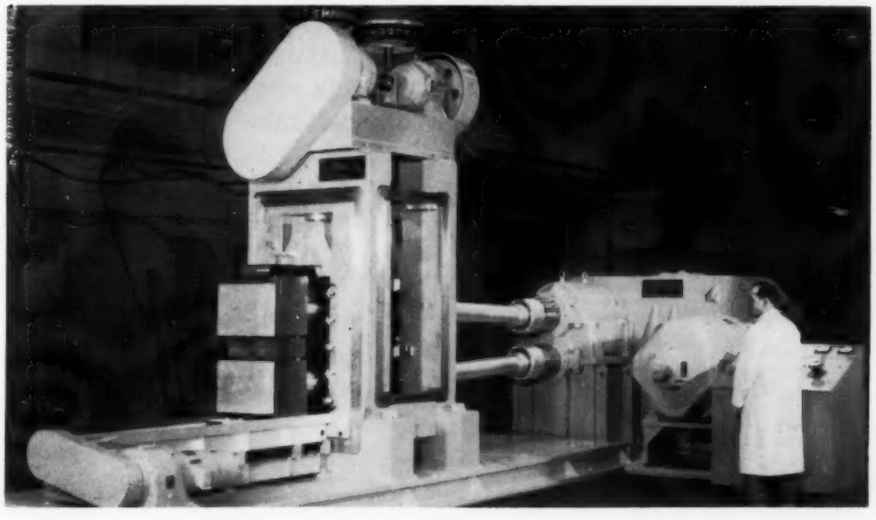
The operation of electric motors within an argon-filled hood is undesirable since the argon atoms are easily ionized, thus causing insulation breakdowns. Hence, both the main mill motor and auxiliary motors for screwdown and roll changing drives are mounted outside the hood, to operate in air.

The new machine is a 20-in. wide, 2-high/4-high combination rolling mill employing 3-in. diam work rolls and 14-in. diam backup rolls. An outstanding feature of the mill is its power-operated roll change mechanism which facilitates removal and replacement of various types of rolls within the glovebox area. The roll change mechanism not only accelerates changeover of rolls from 2-high to 4-high operation, and vice versa, but provides safe, remote control handling of rolls assumed to be contaminated beyond tolerance once they enter the mill enclosure. Initially, three roll sets are being supplied with the mill for the following duties:

1. 14 x 20-in., 2-high breakdown rolls for hot working of flat materials at up to 1700 F.
2. 3 and 14 x 20-in., 4-high finishing rolls for cold working of flat materials.
3. 14 x 20-in., 2-high grooved rolls for hot working of shapes in gothic passes from 2 to ½-in. diam.

The use of such interchangeable roll sets on this combination mill allows it to perform the various processing functions which would, in conventional practice, call for a 2-

Figure 1 — The 3 and 14 x 20-in., 2-high/4-high combination rolling mill is built for remote control operation in glovebox enclosure.



high hot breakdown mill, a 2-high cold intermediate mill, a 4-high cold finishing mill and a 2-high rod rolling mill.

The entire machine is of exceptionally rugged construction, having a roll separating force capacity of 800,000 lb at a speed of 100 fpm. The mill housings are of steel construction and the roll journals run in heavy-duty, super-precision cage type needle roller bearings. The remote control power screwdown system consists of two 5-hp gearmotors offering alternate speeds of ¼ and 4 in. per min. An electro-magnetic clutch is provided to connect the two screwdown motors when simultaneous adjustment of mill settings on both sides is required.

A slideway and slide mechanism is provided for roll changing. A lead screw driven by a 5-hp motor actuates the slide which inserts or withdraws the entire roll assembly as a unit. Lever-actuated cam-locks release the upper roll chocks from the screwdown mechanism. Cam-actuated gibs are withdrawn to release the roll assembly from the mill housings. Limit switches prevent overtravel in either direction, and a magnetic brake on the drive provides accurate positioning control. An adjustable clamp type support stand is provided to hold the universal spindles during roll change. These spindles drive the backup rolls in 4-high operation and the work rolls in 2-high operation. Each spindle is capable of transmitting the entire torque of the mill drive at the lowest speed.

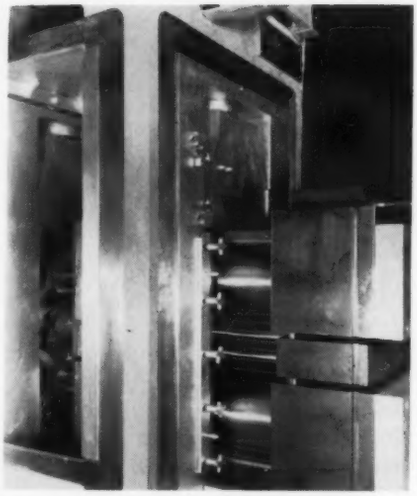


Figure 2 — The 3 and 14 x 20-in., 4-high roll sets are being removed from combination rolling mill by remote control.

The spindles are driven from a fully enclosed pinion stand and gear reducer made in accordance with AGMA Class III standards. Heat-treated alloy steel herringbone gears are used throughout the pinion and reduction gearing, and all gears and pinions are mounted on roller bearings. Force feed lubrication with a recirculating pump and oil reservoir is provided for the gears and their bearings. The entire gear unit can slide on its base to permit the replacement of vacuum seals on the universal spindles when required.

The mill is driven by a 100-hp General Electric "speed variator" set comprising a d-c mill motor, a motor-generator, an operator's console and various control equipment. The drive offers constant horsepower characteristics from 42 to 24-fpm rolling speed and constant torque characteristics from 24 fpm to creeping speed. The provision of a special "amplidyne" rotating regulator permits the mill to be reversed from maximum speed in one direction to maximum speed in the opposite direction in less than three sec. ▲

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produces temperatures never before achieved with oil or natural gas. Burning oil, it can reach a searing 3450°F. On 1000 BTU/cu. ft. natural gas, it develops 3320°F. Both these extremely high temperatures are close to the theoretical limits for these two fuels. Foundries, smelters, heat treaters and other metal processers have been quick to take advantage of the remarkable combustion efficiency of these new burners. To them, it has meant faster heating cycles, cleaner flue gases, and above all, fuel economy that cuts from 12% to 30% from their furnace overhead. Not to speak of reduced maintenance on refractory linings.

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While the number of products has grown, Mid-States, with the cooperation of Cities Service Lubrication Engineer "Ken" Mosher, have constantly studied their lubrication requirements and have reduced the number of individual lubricants. Pacemaker oil serves as a hydraulic oil and also as a lubricant on many machines. Cities Service multi-purpose Trojan H grease does triple duty throughout the plant. Cutting oils and other lubricants are held to a minimum by selecting a quality lubricant to serve several applications. Reducing the number of lubricants saves valuable warehouse space and cuts the chance of error in servicing machines.

Call your local Cities Service office for a Lubrication Engineer to show you how you can reduce your lubricant inventory. Or for full information write: Cities Service Oil Company, Sixty Wall Tower, N. Y. 5, N. Y.

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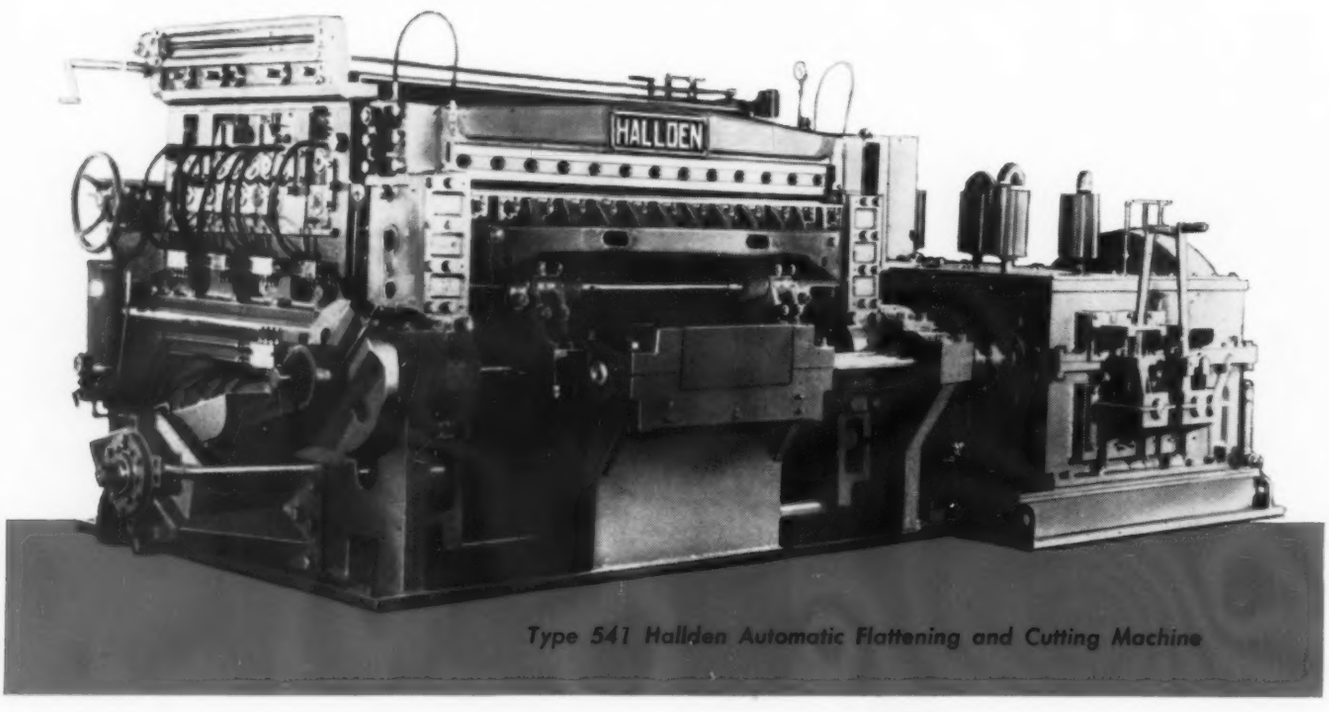

Type 541 Hallden Automatic Flattening and Cutting Machine

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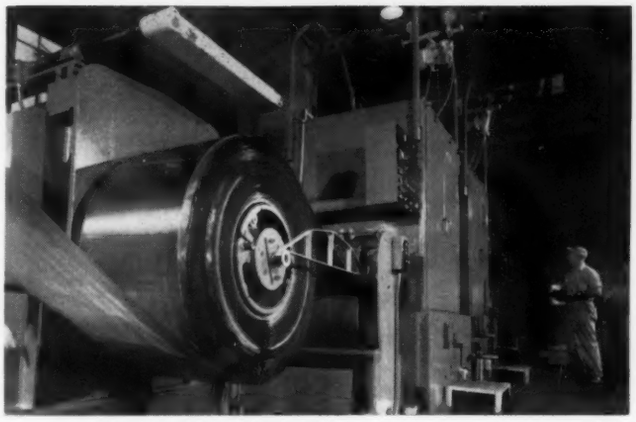


Figure 1 — The new wide-belt oil grinding line viewed from what is normally the takedown or output end. Protective paper is fed to the coil from the extreme left. Weight of a single coil often exceeds five tons. Maximum width of strip ground at Wallingford Steel Co. is 27 in.

Figure 2 — The operator at right is checking thickness (and flatness) readings from the x-ray gage between the two machines. Normally, the work travels from right to left.

Belt Grinding Betters Stainless Tolerances

AN abrasive belt grinding line which produces "machined quality" stainless steel is in operation at the Wallingford Steel Co. plant at Wallingford, Conn.

The new equipment saves nearly two-thirds of previous grinding costs. It benefits fabricators and other users by holding thickness variations across the width of stainless strip to less than 0.0005 in. Thanks to this unique crown grinding feature, Wallingford is able to supply strip that will meet and improve on the exacting tolerances being specified for aircraft, missiles and space vehicles.

The two grinders, with their coated abrasive belts running in oil, were built by The Hill Acme Co. according to designs modified by abrasives engineers of Behr-Manning Co. of Troy, N. Y., a division of Norton Co., and by those of Wallingford Steel Co. they represent eight years of joint development work, replace two former grinding lines which included five machines, and produce in one shift the stainless strip which formerly required three, while improving quality substantially.

Another economy being realized with the new line is the ability to salvage entire coils which formerly had to be shipped back to the mill

Figure 3 — A 30-in. wide coated abrasive belt is removing crown at a surface speed of 4200 fpm, using a knurled steel contact roll. Oil floods each grinding head at the rate of 65 gpm.

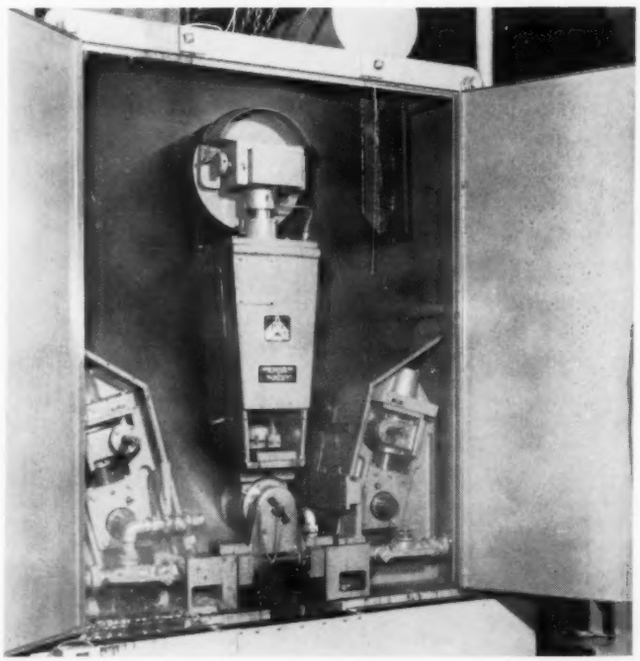
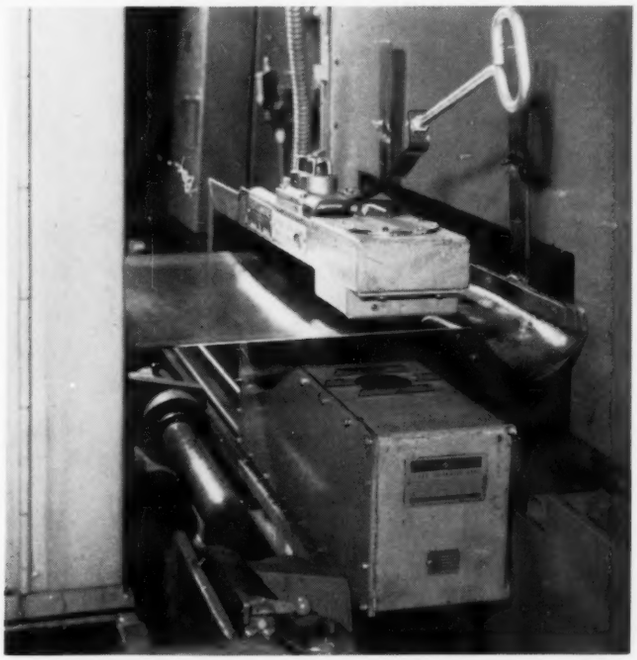


Figure 4 — Thickness of the strip is gaged by x-ray at several points across its width. The recording unit above the strip operates a tracer stylus in a console remote from the grinders. The polished rod at left center is the hydraulic piston rod which traverses the gage automatically.



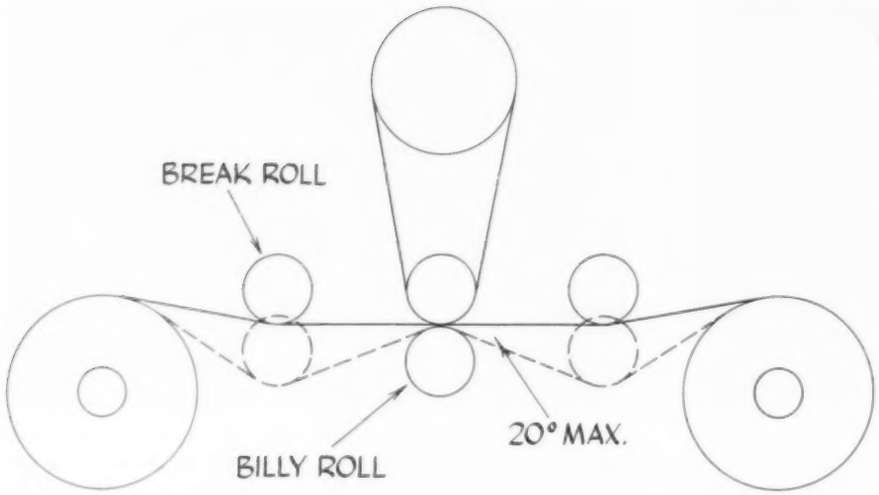


Figure 5 — This schematic shows how the break rolls flatten the strip as it approaches and leaves the grinding point, defeating its tendency, developed earlier in rolling, to curl or bow. The break rolls are positioned positively by manual screw-thread adjustment. The contact roll (immediately above the billy roll) may be of knurled steel for tolerance grinding or serrated rubber for stock removal and finishing.

for remelting. Frequently, imperfections were too deep for the old dry grinding lines to handle—a condition most commonly met with the exotic metals such as titanium and zirconium, and with special alloys.

Early estimates pointed to probable savings with the new line, in direct labor cost and that of abrasive belts alone, of nearly $91,000 per year. It has already become clear that savings will exceed that rate. About 25 per cent of the plant's production will be ground on the new line; significantly, a 10-coil order can now be filled in 12 hr, instead of the 65 formerly required.

The ability to remove crown was the key factor that led Wallingford to invest the nearly $300,000 which the new line cost.

With this line, Wallingford is already shipping stainless strip ground to a flatness which meets aircraft and missile specifications. Those industries have been clamoring for such strip for at least four years, but the steel industry has had no way to supply it. Such a product will also offer great advantages for countless conventional applications as well.

The grinding line consists basically of two 60-hp vertical grinders running in tandem, each driving 30 x 126-in. cloth belts, all-resin bonded, with aluminum oxide or silicon carbide abrasives. Unlike earlier dry grinding equipment at Wallingford, these belts grind in a flood of sulphur-chlorinated oil pumped to each grinding head at 65 gpm (maximum capacity 100 gal) from a 4000-gal reservoir and filtration system. When high polishes are required, less aggressive glue-bonded belts of cloth or paper will be used.

Several novel features combined to flatten the strip as it approaches the abrasive belt: the coil is under endwise tension of 30,000 lb, and it is sharply bent, at angles up to 20 degrees, by being forced under "break" rolls as it approaches and leaves the grinding point. Also, a solid steel billy roll or work-support roll eight in. in diameter forces the strip against the belt by hydraulic pressure. With such heavy components, the machines can handle strip to 0.240 in. in thickness.

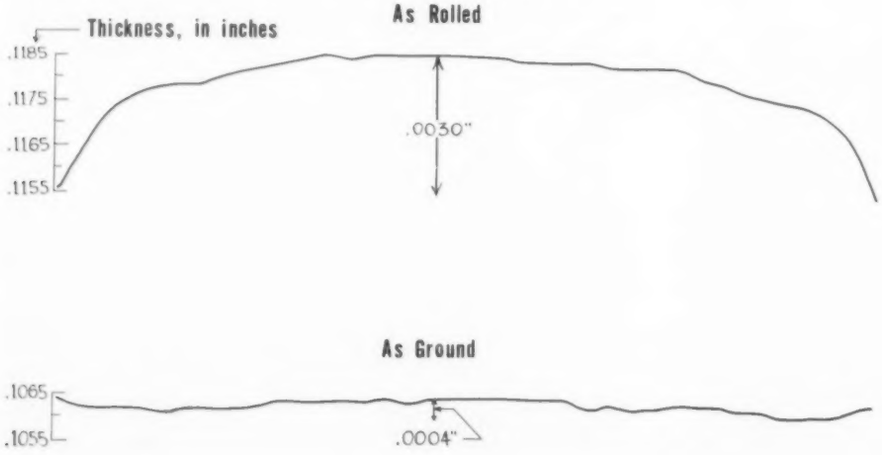
Contact rolls are knurled steel or serrated rubber, in a range from 45 to 90 Durometer, dynamically balanced. They operate at 900 and 1800 rpm to give belt speeds of 2100 or 4200 surface fpm. Work is fed to the abrasive belts at speeds usually between 6 and 36 fpm, depending on the depth of cut, type of stock and the surface finish desired.

On tube-mill stock, for example, a typical sequence for adequate stock removal with the best finish and maximum production would use 90 Durometer serrated rubber contact rolls on both grinders, with land and groove width equal at 3/8 in. for maximum aggressiveness. With feed speeds of 18 to 20 fpm depending on the severity of imperfections, the first grinder would operate at 2100-fpm belt speed, using a new 80-grit aluminum oxide belt; the second would run at 4200 sfpm. Each side of the strip would receive one pass.

A comparison of oil vs dry grinding on tube-mill stock shows one pass as against three, one belt consumed instead of four and one-half belts, and 63 min required instead of 134. These processing times include coil handling.

Instrumentation and accessory equipment are complete and often unique. An x-ray gage automatically traversed across the strip records thickness on a moving reel of paper. In addition to the huge Delpark filtration system, which delivers collected swarf to a self-dumping hopper on the finishing room floor, Precipitrons extract oil vapor from the exhaust system. A spot welder attaches lead strips to the leading end of each coil. Integral power hoists with canvas slings handle changes of the heavy contact rolls. Circuitry is fail-safe throughout; belt breakage or lowered oil level shut off all power instantly and apply brakes to rotating parts. Finally, a fire extinguisher system has its discharge nozzles focussed on grinding heads and filter tanks. ▲

Figure 6 — Profiles show effect of grinding on strip gage.



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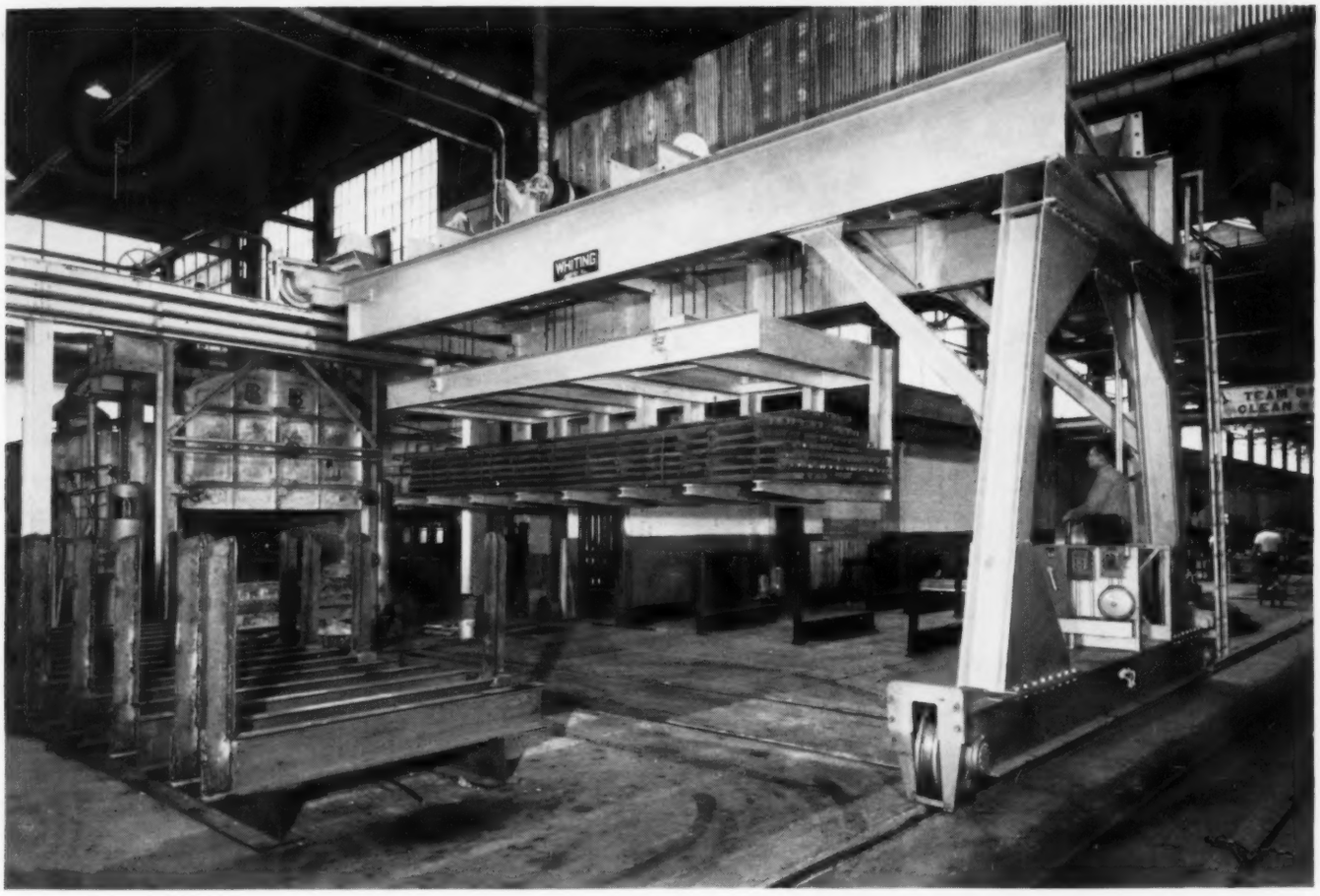

The Whiting gantry crane **above** relieved a staggering bottleneck at Bliss & Laughlin's busy mill in Harvey, Illinois. Four heat treating furnaces are now speedily loaded and unloaded in contrast to a system that was arduous, time-consuming and costly. The new gantry has stepped up furnace capacity over 20% and cut maintenance on furnaces and loading cars. B.&L.'s service to customers has greatly improved.

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Date-line Diary...

October 3

△ Joint report from American Iron Ore Assn. and AISI indicates receipts of iron ore and iron ore agglomerates in the U. S. for August, 1960, totaled 13,894,101 gross tons compared with 3,083,069 in August, 1959. Stocks on hand as of August 31, 1960, totaled 62,952,616 compared with 49,498,306 tons on August 31, 1959. Blast furnaces in operation on August 31 were 129 of the total 258. On August 31, 1959, 34 blast furnaces were in operation.

△ The Bureau of the Census reported that shipments of nonferrous castings in the United States in July, 1960, totaled 132,383,000 lb compared with 179,521,000 lb in June, 1960.

△ Phoenix Steel Corp. purchased the Claymont, Del., plant from the Colorado Fuel and Iron Corp. The transaction will increase Phoenix's annual capacity to 1,353,260 tons; CF&I's capacity will be cut to 2,330,000 tons.

△ AISI reports that shipments of finished steel products during August, 1960, total 5,071,953 net tons compared with 4,710,565 tons in July, 1960, and 1,338,609 tons in August, 1959.

△ The AISI reports that the operating rate of the steel industry for the week of October 3, is scheduled at 1,500,000 tons (52.6 per cent of capacity). This compares with 1,558,000 tons one week ago (54.7 per cent capacity) and 362,000 tons one year ago. Index of production for the week is 93.4.

October 4

△ Steel scrap prices in Pittsburgh declined $3.50 to $5.50 a ton; No. 1 railroad heavy melting scrap sold at $31.50 a ton down from $35.00, old car wheels dropped to $38.11 from $43.75 in September.

△ Custom smelters reduced copper prices 2¢ to 31¢ a lb.

△ The AISI reports that the steel industry's employment of hourly and salaried works in August, 1960, totaled $300,259,708, compared with $286,967,361 in July, 1960; total employed equalled 542,668 in August against 554,069 in July; payroll cost per hour worked by hourly employees, $3.313 in August, 1960, against $3.382 in July, not including 45¢ supplemental employee benefits. Average hours per week worked was 34.2 during August, 1960, against 30.6 in July.

October 5

△ Budget Director Stans forecasts that the budget for the fiscal year ending June 30, 1961, is expected to show a surplus of only $1,100,000,000 instead of the $4,200,000,000 predicted by the President in January, 1960.

△ The nation's production of goods and services in the third quarter of 1960 held at about the same level as the second quarter's seasonally adjusted annual rate of $505,000,000,000.

△ The American Iron Ore Assn. reports that shipments of iron ore down the Great Lakes in September, 1960, totaled 8,361,220 gross tons an increase of 7,590,522 tons over the 770,698 tons in September, 1959.

△ Can Manufacturers Institute, Inc., reports that steel consumed in July, 1960, in production of tinplate cans totaled 453,187 tons, a decrease of 9.9 per cent from July, 1959.

△ The Bureau of the Census reports that shipments of iron and steel castings in July, 1960, totaled 942,731 short tons compared with 1,259,223 tons in June, 1960, and 1,107,672 tons in July, 1959.

△ The AISI reports that wage supplements (fringe benefits) in 1959 totaled $543,100,000 (19 per cent of total employment costs for wage earners) compared with $98,900,000 in 1947 (6 per cent).

October 7

△ Auto dealers sold 422,700 U.S. built cars in September, 1960, an increase of 21 per cent over September, 1959.

△ The Treasury announced plans to sell at auction on October 18, a $3,500,000,000 issue of 244-day tax anticipation bills, and on October 11 will make an offering of $1,500,000,000 of new one-year bills. These two offerings are aimed at financing Government seasonal needs of $3,000,000,000 and a $2,000,000,000 issue of one-year bills maturing October 17.

△ The Census bureau reported that U. S. imports of foreign goods in August, 1960, rose to $1,200,000,000, an increase of 6 per cent over July, 1960, and 3 per cent over August, 1959.

△ The Aluminum Assn. reports that net shipments of aluminum sheet and plate in August, 1960, totaled 114,784,000 lb, compared with 121,215,000 lb in July, 1960. Shipments of aluminum foil in August, 1960, totaled 20,719,831 lb compared with 18,003,505 lb in July, 1960.

October 10

△ The AISI reports that the operating rate of the steel industry for the week of October 10, is scheduled at 1,556,000 tons (54.6 per cent of capacity). This compares with 1,522,000 tons one week ago (53.4 per cent capacity) and 368,000 tons one year ago. Index of production for the week is 96.9.

△ The U. S. Dept. of the Interior, Bureau of Mines, reports that production of Pennsylvania anthracite in September, 1960, totaled 1,518,000 net tons compared with 1,637,000 tons in August, 1960, and 1,823,000 tons in September, 1959.

△ The Bureau of Mines reported that consumption of scrap in August, 1960, totaled 4,182,000 gross tons compared with 3,678,127 tons in July, 1960; pig iron consumption totaled in August, 1960, 4,124,000 gross tons compared with 3,887,909 tons in July, 1960.

October 11

△ The Labor Dept. reported that unemployment in September, 1960, totaled 3,388,000 a decrease of 400,000 from August, 1960. September, 1960, employment totaled 67,767,000 down 515,000 from August, 1960.

△ The Commerce Dept. reported advance surveys showed retail sales in September totaled $18,000,000,000 after seasonal adjustment, down 1 per cent from August, 1960.

△ The Bureau of the Census reported that shipments of commercial steel forgings in August, 1960, totaled 89,355 short tons compared with 79,258 tons in July, 1960, and 97,900 tons in August, 1959.

△ The Bureau of Statistics (Canada) reported that production of steel ingots totaled 441,753 tons in September, 1960, compared with 491,638 tons in September, 1959. Production of pig iron in September, 1960, amounted to 342,680 tons, compared with 362,421 tons in September, 1959.

October 12

Δ Key steel scrap grades at Chicago declined $1 a ton, with No. 1 dealer heavy melting selling at $27 a ton delivered; No. 1 heavy melting steel scrap sold at $29 a ton.

Δ Kennecott Copper Corp. and Phelps Dodge cut price of Copper 3¢ to 30¢ per lb.

October 13

Δ Copper price in Canada was reduced 1½ to 28½¢ by International Nickel Co.

October 14

Δ Commerce Dept. reported that personal income in September, 1960, rose to a seasonally adjusted annual rate of $408,400,000,000, up $200,000,000 from August, 1960 pace.

Δ General Electric reported that third quarter, 1960 sales totaled $1,030,254,000, down 4 per cent from the like 1959 period; net earnings in the third quarter of 1960 totaled $57,506,000, a decrease of 20 per cent from the third quarter in 1959. Net sales for the first nine months of 1960 totaled $3,053,223,000, down 3 per cent from the 1959 period; and net earnings totaled $168,935,000, down 11 per cent from the first nine months in 1959.

Δ Westinghouse Electric Corp. reports that for the third quarter in 1960, sales totaled $503,389,000, net income $20,226,000 or 57¢ a share compared with 1959 third quarter sales of $494,189,000, net income of $22,075,000 or 63¢ a share. For the first nine months of 1960 sales totaled $1,457,233,000, and net income amounted to $60,680,000 or $1.71 a share compared to this period of 1959 when sales totaled $1,408,393,000 and net income of $56,225,000 or $1.59 a share.

October 17

Δ The AISI reports that the operating rate of the steel industry for the week of October 17 is scheduled at 1,556,000 tons (54.6 per cent of capacity). This compares with 1,579,000 tons one week ago (55.4 per cent capacity) and 371,000 tons one year ago. Index of production for the week is 96.9.

October 19

Δ The Census Bureau reported that private housing starts in September, 1960, fell to a seasonally adjusted annual rate of 1,077,000, 17 per cent below the August, 1960, pace and 29 per cent lower than in September, 1959.

Δ The Can Manufacturers Institute reported that steel consumed in tinplate cans in August, 1960, totaled 600,601 tons, a decrease of 1.9 per cent from August, 1959.

Δ The Aluminum Assn. reports that production of primary aluminum in the United States in September, 1960, totals 162,882 short tons compared with 172,973 tons in August, 1960, and 168,205 tons in Sept. 1959.

October 24

Δ The ARCI reported that deliveries of new freight cars in September, 1960, totaled 4265 compared with 4124 cars in August, 1960, and 2605 cars in September, 1959. Orders in September, 1960, totaled 2061, compared with 1343 in August, 1960, and 943 in September, 1959. Backlog of cars on order as of October 1, 1960, totaled 21,662, compared with 23,866 on September 1, 1960, and 35,626 on October 1, 1959.

Δ GE and the International Union of Electrical Workers signed a three-year contract providing an initial 3 per cent wage increase.

Δ The AISI reports that the operating rate of the steel industry for the week of October 24, is scheduled at 1,516,000 tons (53.2 per cent of capacity). This compares with 1,579,000 tons one week ago (55.4 per cent capacity) and 371,000 tons one year ago. Index of production for the week is 94.4.

Δ Allis-Chalmers Mfg. Co. reported for the third quarter nine months ending September 30, 1960, respectively, sales totaling $126,698,400 and $409,389,500, net earnings totaling $1,251,383 and $9,031,528, compared with 1959 sales for the same period totaling $387,849,262, and net income of $15,454,928.

October 25

Δ Allegheny-Ludlum Steel Corp., of Brackenridge, Pa., Societe Anonyme Metallurgique d'Esperance-Longdoz, of Liege, Belgium, and its parent concern, Evence Coppee & Cie of Brussels have joined to form a company to make and sell specialty steels in European and world markets. The plant is to be built in Belgium, will produce stainless and specialty steels, at a cost of more than $10,000,000. Allegheny Ludlum will have a half interest in the plant and its investment will be at least $5,000,000 by the time operation begins.

Δ AISC reports that shipments of fabricated structural steel in September, 1960, totaled 323,516 tons compared with 331,932 tons in August, 1960, and 182,596 tons in September, 1959. Bookings in September, 1960, totaled 259,986 tons compared with 261,976 tons in August, 1960, and 284,114 tons in September, 1959. Backlog as of September 30, 1960, amounted to 2,058,047 tons.

October 27

Δ The Labor Dept. reported that the Government's consumer price index rose to 126.8 per cent of the 1947–49 average in September, compared with 126.6 per cent in August, 1960.

Δ National Machine Tool Builders Assn. reported that new orders for machine tools in September totaled $52,350,000, shipments totaled $54,300,000; compared with August, 1960, new orders totaling $56,850,000, shipments totaling $47,900,000.

October 31

Δ The Commerce Dept. reported that manufacturing firms' incoming business in September, 1960, rose to a seasonally adjusted $30,400,000,000 compared with $30,000,000,000 in August, 1960.

Δ Carpenter Steel Co. reported for the fiscal year ending June 30, 1960, sales totaling $85,065,230, net income totaling $8,773,012 or $3.50 a share, compared with 1959 sales totaling $68,950,857, net income $4,594,850 or $2.33 a share.

Δ The Commerce Dept. estimated that exports of of goods overseas in September, 1960, totaled $1,574,000,000 a gain of 2 per cent over August, 1960, and 13 per cent above September, 1959.

Δ The AISI reports that the operating rate of the steel industry for the week of October 31 is scheduled at 1,473,000 (51.7 per cent of capacity). This compares with 1,545,000 tons one week ago (54.2 per cent capacity) and 368,000 tons one year ago. Index of production for the week is 91.7.

Δ The Bureau of the Census reported that shipments of nonferrous castings in August, 1960, totaled 171,182,000 lb, compared with 132,336,000 lb in July, 1960.

Δ The Bureau of the Census reports that net shipments of aluminum pig and ingot for August, 1960, totaled 164,033,000 lb compared with 102,398,000 lb in July, 1960, and 66,637,000 lb in August, 1959. Shipments of aluminum mill products in August, 1960, totaled 258,660,000 lb compared with 253,141,000 lb in July, 1960, and 247,610,000 lb in August, 1959.

Δ Joint report from American Iron Ore Assn. and

STEEL COMPANIES QUARTERLY FINANCIAL REPORTS—JULY 1, 1960 TO SEPTEMBER 30, 1960

	Period	1960 Gross income	1960 Net profits	1960 Earnings per share	1959 Gross income	1959 Net profits	1959 Earnings per share
Acme Steel Co.	3rd quar.	$ 29,810,603	$ (211,261)	$ ...	$ 15,917,531	$ (1,556,335)	$...
	9 mo.	112,436,722	2,409,655	0.75	105,698,246	2,961,283	0.97
Alan Wood Steel Co.	3rd quar.	11,394,000	(82,000)	...	19,320,000	985,000	1.33
	9 mo.	48,363,000	1,123,000	1.35	58,648,000	3,082,000	4.17
Allegheny Ludlum Steel Corp.	3rd quar.	50,282,170	647,902	0.17	18,248,896	(3,913,320)	(1.01)
	9 mo.	185,680,731	6,180,486	1.59	181,246,918	8,455,688	2.19
Armco Steel Corp.	3rd quar.	213,474,758	11,693,836	0.79	188,644,154	8,852,696	0.60
	9 mo.	734,656,139	53,427,055	3.61	780,649,220	59,445,964	4.02
Atlas Steels, Ltd.	3rd quar.	...	547,100	0.50	...	605,000	0.55
	9 mo.	...	2,247,800	2.06	...	2,365,000	2.17
Bethlehem Steel Corp.	3rd quar.	502,981,428	12,436,106	0.24	198,676,783	(38,926,913)	...
	9 mo.	1,727,833,816	93,979,141	1.96	1,646,822,901	84,231,916	1.75
Carpenter Steel Co.	1st quar.	15,281,606	687,835	0.36	19,195,013	1,573,368	0.84
Colorado Fuel & Iron	3rd quar.	...	(5,615,161)	...	...	(6,224,477)	...
	9 mo.	...	(3,200,729)	...	...	6,364,283	1.67
Continental Steel Corp.	3rd quar.	10,760,371	812,958	0.79	12,027,378	1,057,379	1.02
	9 mo.	36,670,853	3,121,600	3.03	42,345,984	3,845,836	3.72
Copperweld Steel Co.	3rd quar.	22,150,312	(40,443)	...	26,528,845	684,775	0.59
	9 mo.	91,094,156	2,213,074	1.88	101,083,020	4,182,573	3.67
Crucible Steel Corp. of America	3rd quar.	42,046,837	(1,825,711)	...	24,566,607	(2,034,090)	...
	9 mo.	166,715,189	1,208,432	0.21	179,133,564	6,586,971	1.66
Detroit Steel Corp.	3rd quar.	16,914,320	100,533	0.01	25,464,539	2,844,530	0.71
	9 mo.	72,718,356	4,307,998	1.09	82,625,825	8,637,565	2.20
Eastern Stainless Steel Corp.	3rd quar.	12,833,033	87,810	0.06	14,666,380	713,130	0.50
	9 mo.	47,631,924	1,313,476	0.91	51,080,777	2,342,486	1.63
Edgewater Steel Co.	3rd quar.	...	74,906	0.40	...	...	...
	9 mo.	...	359,814	1.92	...	...	...
Granite City Steel Co.	3rd quar.	28,833,364	1,789,858	0.42	34,431,230	3,260,008	0.76
	9 mo.	110,322,405	9,427,409	2.20	119,604,628	11,630,334	2.71
Inland Steel Co.	3rd quar.	166,661,366	5,135,369	0.28	105,967,304	(7,449,109)	(0.43)
	9 mo.	598,751,328	38,202,872	2.17	575,172,705	34,723,272	1.99
Interlake Iron Corp.	3rd quar.		515,502	0.23		587,956	0.26
	9 mo.	72,117,486	3,982,642	1.77	89,526,181	6,176,145	2.75
Jones & Laughlin Steel Corp.	3rd quar.	164,196,000	3,483,000	0.40	66,674,000	(16,465,000)	(2.15)
	9 mo.	625,784,000	29,619,000	3.63	619,442,000	25,741,000	3.15
Kaiser Steel Corp.	3rd quar.	46,207,920	(5,802,364)	(2.02)	13,016,431	(10,894,581)	...
	9 mo.	164,869,872	(1,072,560)	(0.42)	160,305,394	(696,874)	(0.97)
Keystone Steel & Wire Co.	3rd quar.	22,580,099	696,218	0.37	29,677,586	1,813,565	0.97
Lone Star Steel Co.	9 mo.	46,620,163	3,912,602	1.00	80,551,650	10,022,477	2.55
Lukens Steel Co.	36 weeks*	74,866,583	3,325,768	3.49	68,703,921	3,097,940	3.24
McLouth Steel Corp.	3rd quar.	...	3,445,658	0.95	...	(3,193,566)	...
	9 mo.	...	13,120,965	3.62	...	7,463,567	1.95
National Steel Corp.	3rd quar.	163,457,628	8,061,074	1.06	128,445,011	2,821,600	0.36
	9 mo.	557,706,440	35,362,435	4.67	567,175,136	42,282,708	5.62
Phoenix Steel Corp.	3rd quar.	6,640,000	(568,000)	...	14,858,000	489,000	0.47
	9 mo.	31,480,000	(727,000)	...	40,768,000	978,500	0.94
Pittsburgh Steel Co.	3rd quar.	26,942,897	(671,040)	...	6,507,028	(4,105,001)	...
	9 mo.	114,796,371	1,734,154	0.47	120,241,405	(63,483)	...
Republic Steel Corp.	3rd quar.	218,779,420	7,310,271	0.47	65,971,650	(24,861,406)	(1.59)
	9 mo.	862,213,739	48,718,754	3.10	853,157,259	42,228,311	2.69
Sharon Steel Corp.	3rd quar.	22,223,124	(840,342)	...	9,599,472	(1,560,080)	...
	9 mo.	95,108,524	1,466,499	1.33	93,174,182	1,510,825	1.37
Steel Co. of Canada, Ltd.	3rd quar.	64,556,950	...	...	82,342,987	...	...
	9 mo.	220,786,175	...	...	236,632,651	...	...
United States Steel Corp.	3rd quar.	785,249,769	52,415,599	0.85	368,377,469	(31,135,136)	...
	9 mo.	2,975,198,278	245,887,840	4.20	2,894,708,849	223,813,360	3.80
Universal-Cyclops Steel Corp.	3rd quar.	23,821,396	537,428	0.29	22,047,203	361,553	0.19
	9 mo.	...	3,658,254	1.95	...	5,670,733	3.02
Washington Steel Corp.	4th quar.	...	351,035	0.53	...	759,205	1.24
	Fiscal year	...	2,141,535	3.30	...	2,739,675	4.41
Woodward Iron Co.	9 mo.	...	3,843,921	1.50	...	4,336,628	1.70
Wheeling Steel Corp.	3rd quar.	50,662,000	558,000	0.07	17,334,000	(4,263,000)	...
	9 mo.	188,400,000	8,714,000	3.54	173,653,000	6,748,000	2.60
Youngstown Sheet and Tube Co.	3rd quar.	121,686,767	2,676,626	0.77	58,618,449	(7,149,660)	...
	9 mo.	472,090,402	21,565,636	6.19	487,381,809	21,555,145	6.20

* Figures in parentheses indicate losses.

AISI indicates receipts of iron ore and iron ore agglomerates in the U. S. for September, 1960, totaled 11,048,599 gross tons compared with 3,557,596 in September, 1959. Stocks on hand as of September 30, 1960, totaled 67,645,197 gross tons compared with 51,591,715 tons on September 30, 1959. Blast furnaces in operation on September 30 were 136 of the total 258. On September 30, 1959, 33 blast furnaces were in operation.

Δ The Japan Iron & Steel Federation reports that production of ingot steel in August, 1960, totaled 2,049,000 net tons; production of pig iron amounted to 1,100,000 net tons.

Δ The Census Bureau reported that construction outlays in October ran at a seasonally adjusted annual rate of $55,000,000,000 down less than one per cent from the September, 1960, pace.

Δ Frederic G. Donner, chairman, announced General Motors Corp. will spend $1,250,000,000 around the world in 1961 for new plants, machinery, equipment and tooling, an increase of $50,000,000 over capital expenditures in 1960.

CONTROL

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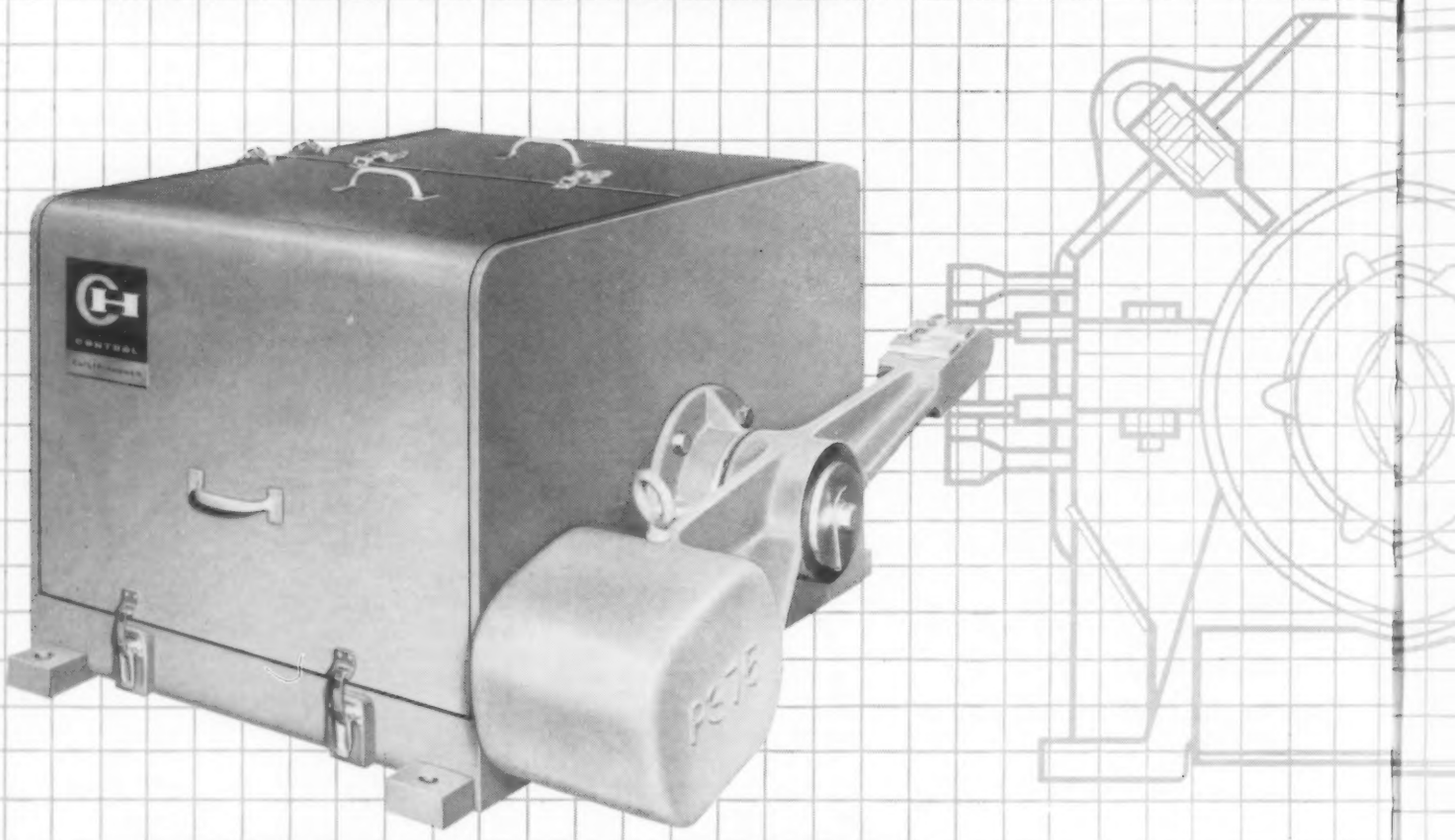

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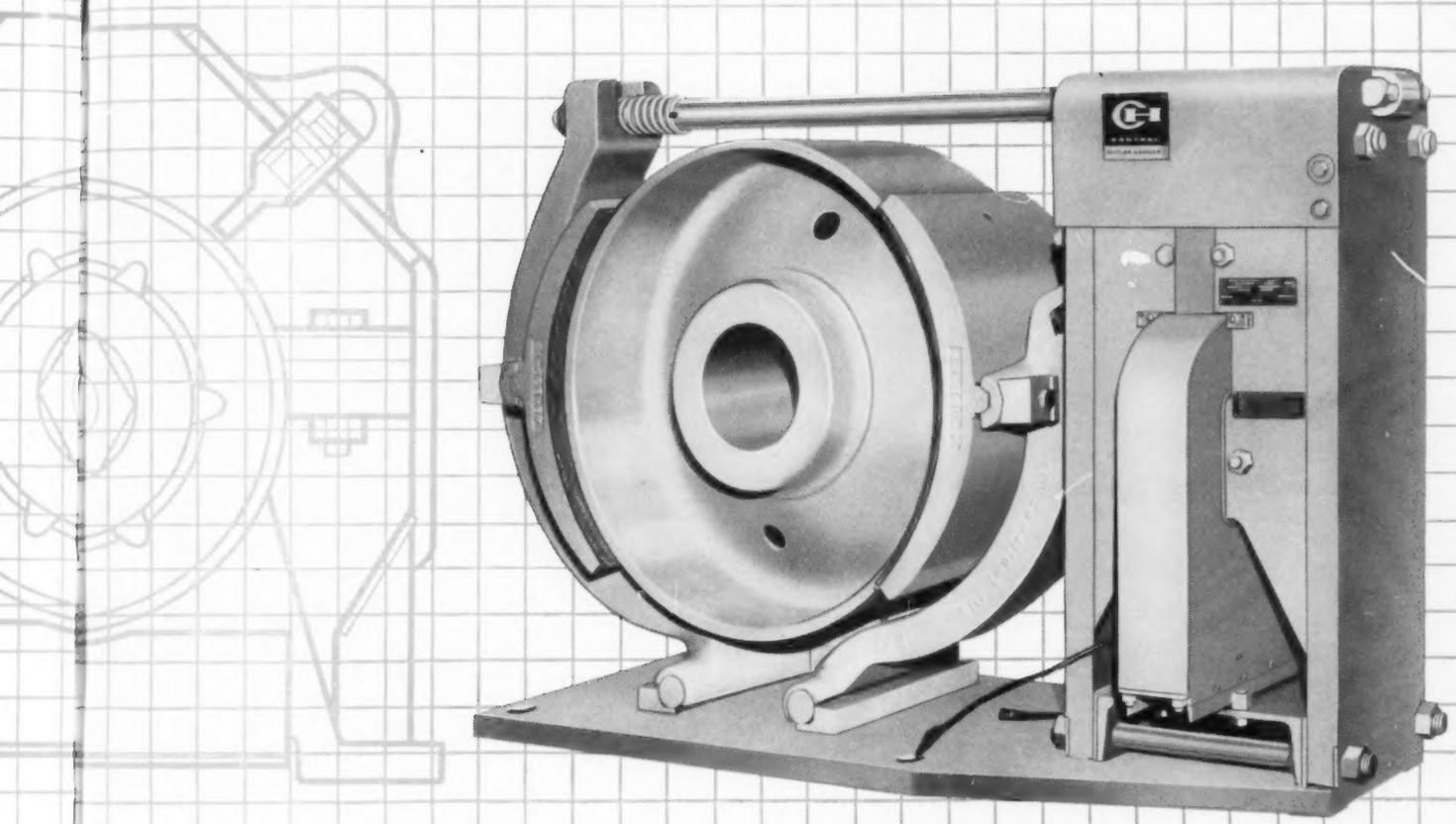

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CONTROL

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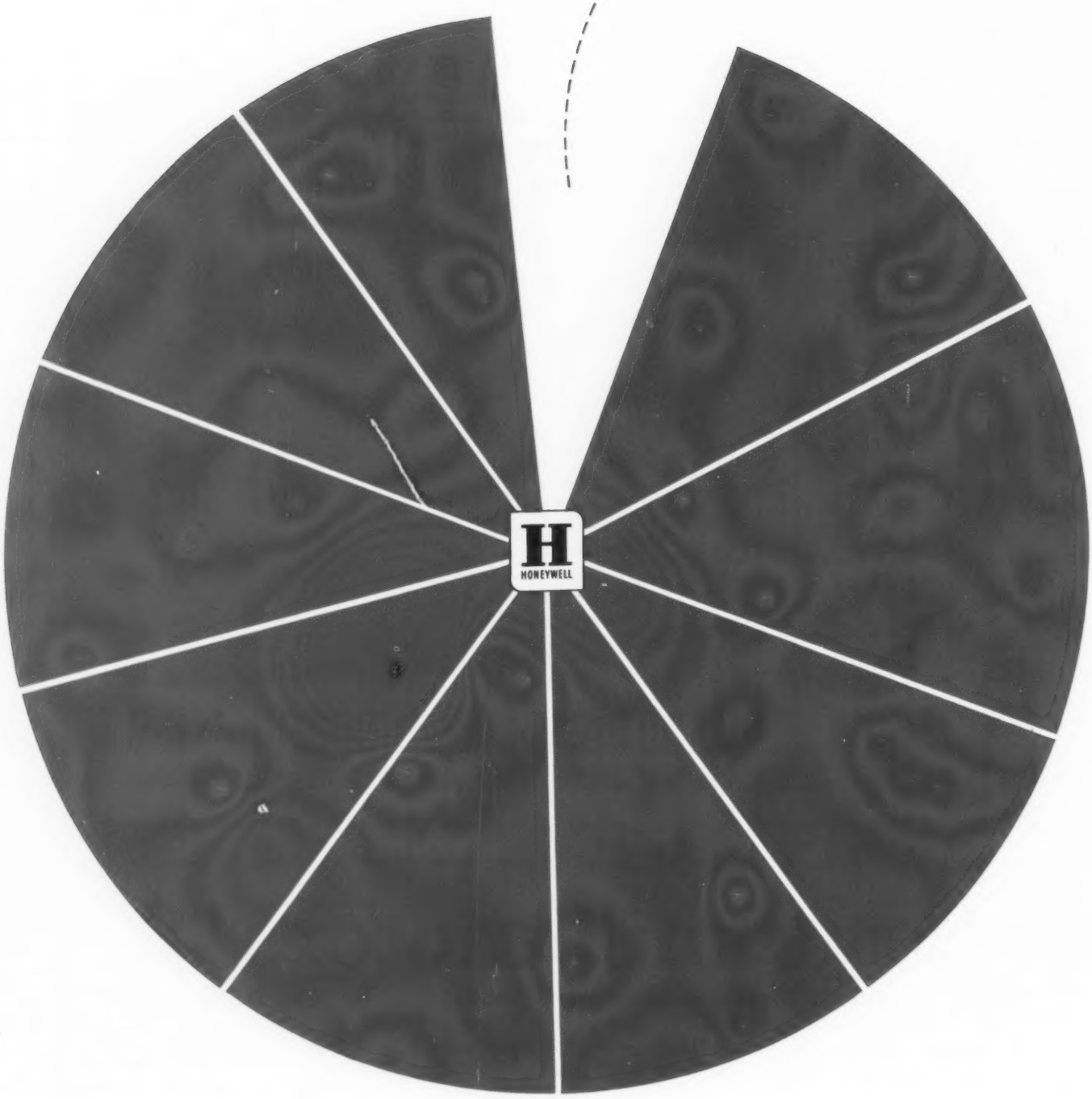

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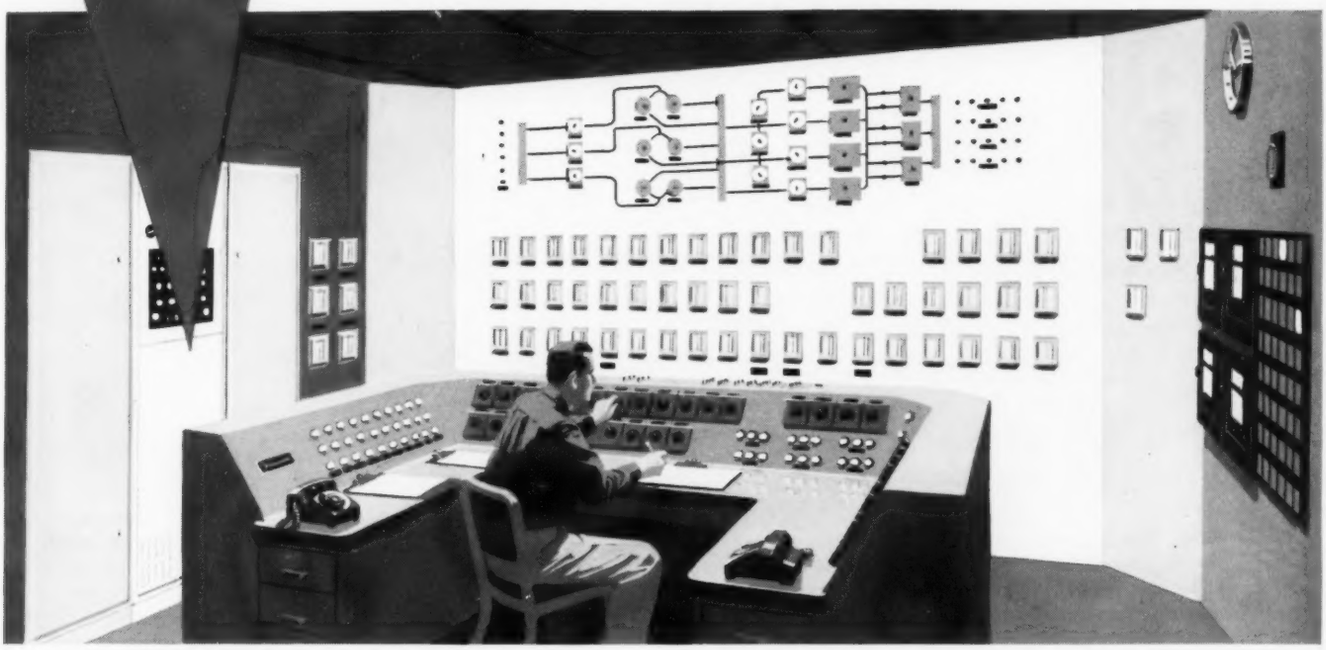

You hear a lot about industrial process computers these days. As processes get bigger, faster and more complex, computers are being used as the reins as well as the brains—for control as well as data reduction—in fields as diverse as ice cream making and petroleum refining.

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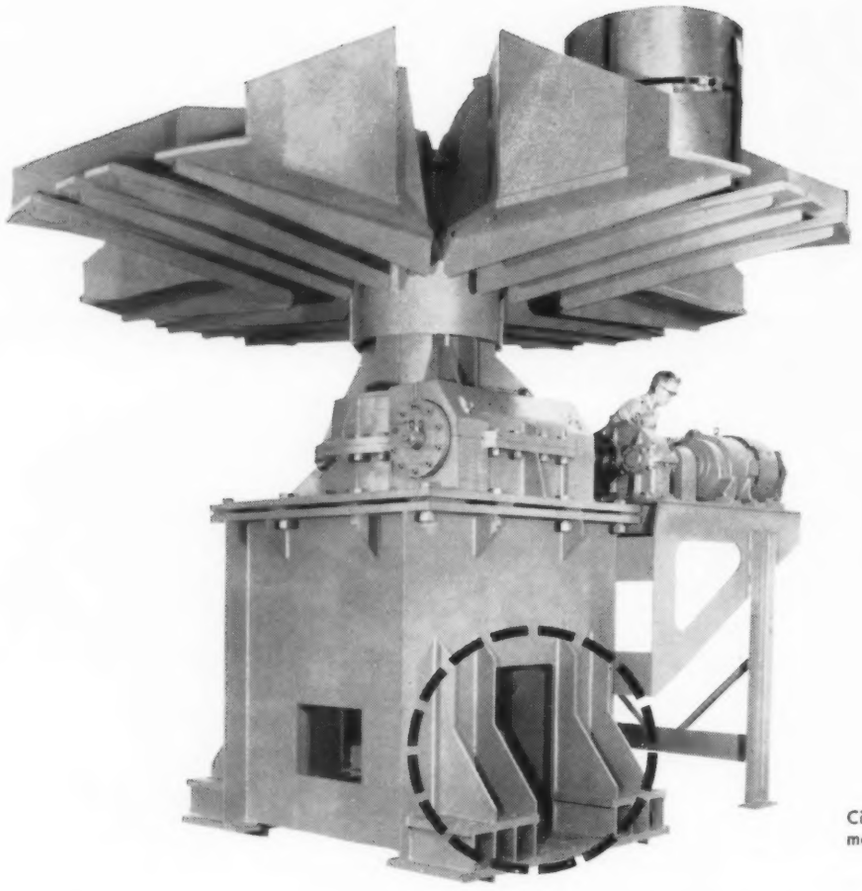

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Maintenance on this Planet 40,000-pound, multi-station coil turner has been simplified by allowing easy access to the hydraulic lift mechanism. Large openings on two sides of the machine's base allow maintenance work and, when necessary, removal of the entire unit *without* disassembling any other part of the turner.

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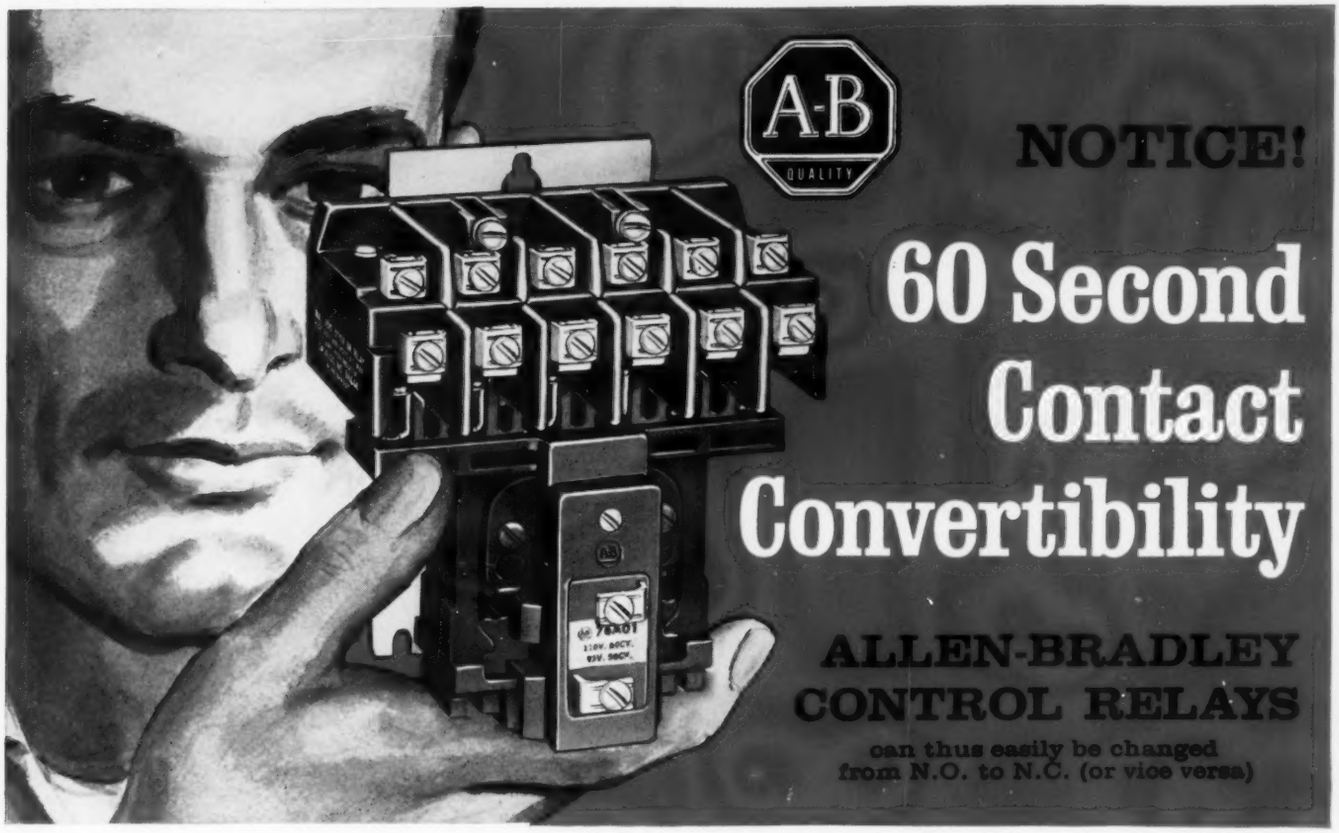
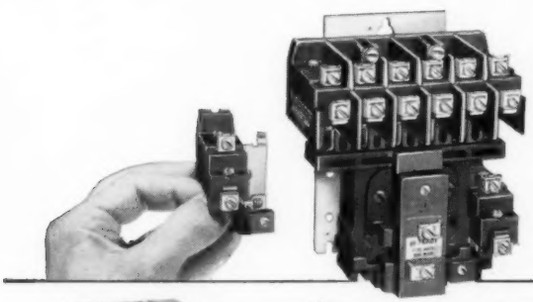


Why not give yourself a real surprise! We refer to the ease with which you can convert the contacts of these Allen-Bradley Bulletin 700 Type BR control relays. Using only a screwdriver, contacts can be changed from normally open to normally closed (or vice versa) in seconds—without removing the relay from its mounting—or its wiring. This "on-the-spot" convertibility certainly suggests an appreciable moneysaving reduction in your relay inventories.

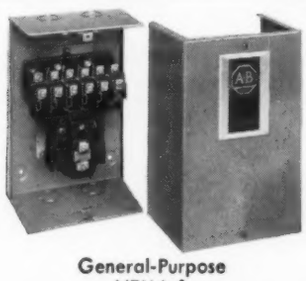
Extensive tests have proven conclusively that the Bulletin 700 Type BR relays are good for many—and we mean *many*—millions of trouble free operations. A "built-in" permanent air gap completely eliminates all possibility of magnetic sticking. Naturally, the double break, silver contacts never need attention. Also, the molded coil is your assurance that even the most severe atmospheric conditions cannot cause trouble. Please write for full details on these relays today!



BUT HEAR THIS!

In the event that when "on-the-job" it is discovered that something was either overlooked or added, the standard Bulletin 700 Type BR—either 2, 3, 4, or 6 pole relay—can easily have added to its base, out in the field, either one or two switching poles. It is done as easily as "falling off a log."

FIVE RELAYS
IN ONE
This shows how a Type BR relay can be arranged —in seconds—to do the job of five different relays.
3 N.C.—1 N.O.
3 N.O.—1 N.C.
4 N.C.
2 N.O.—2 N.C.
4 N.O.



General-Purpose
NEMA 1

Explosion-proof
NEMA 7

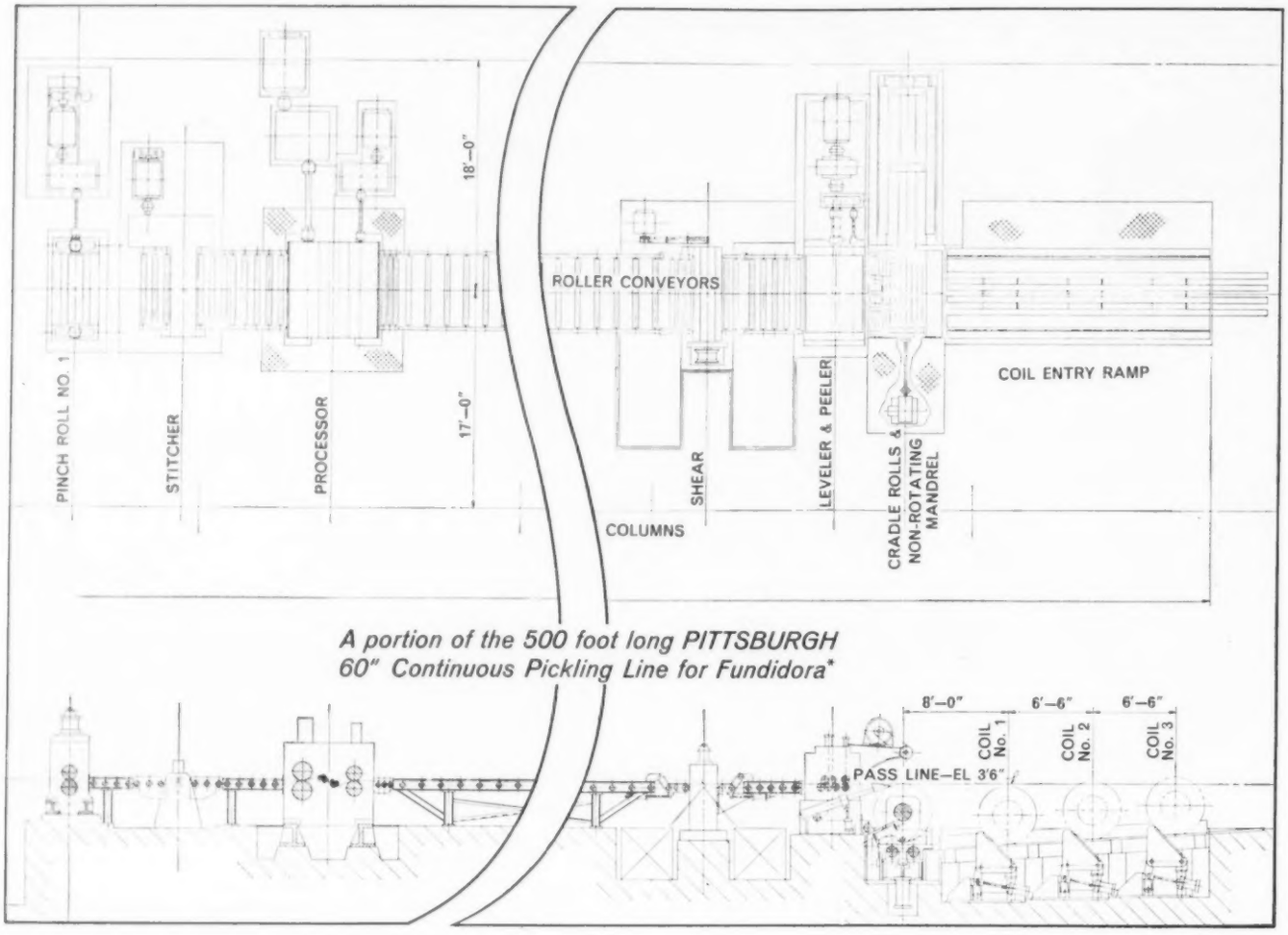
Waterproof
NEMA 4

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1343 S. First St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL



*A portion of the 500 foot long PITTSBURGH 60" Continuous Pickling Line for Fundidora**

*Fundidora** Chooses a PITTSBURGH Continuous Pickling Line in its Plant Expansion Program

Electric and open hearth steel castings from 1 lb. to 100 tons

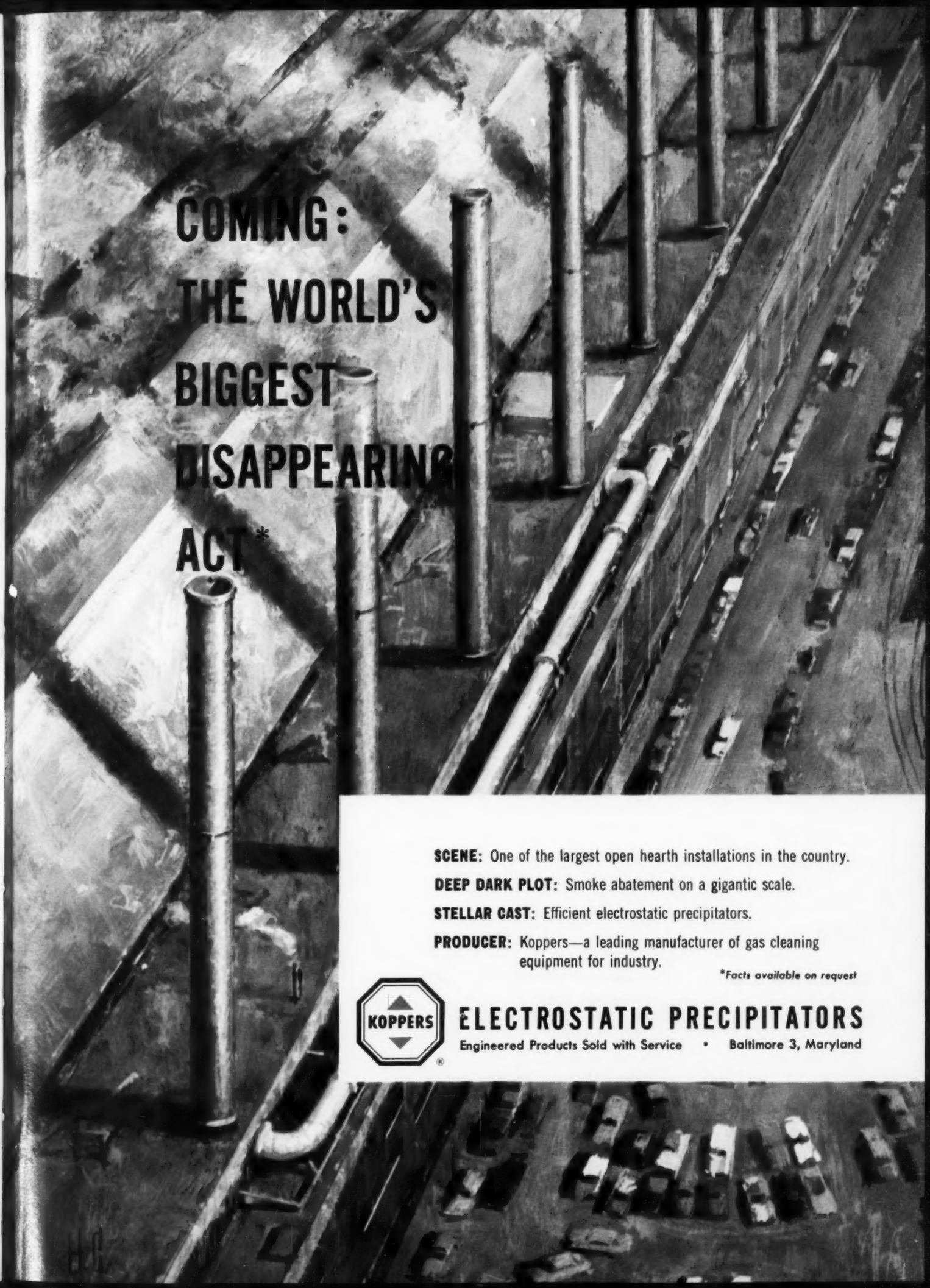
A PITTSBURGH 60" Continuous Pickling Line has been specified for expanded plant facilities at Cia Fundidora De Fierro y Acero De Monterrey, S. A.* as part of the company's multi-million dollar expansion program to meet the growing demand for steel in Mexico. This installation is typical of the primary and auxiliary rolling mill equipment PITTSBURGH designs and manufactures for the steel industry to exacting customer requirements. We can help you in your requirements. Your inquiries are invited.

PITTSBURGH

ENGINEERING & MACHINE DIVISION

Pittsburgh Steel Foundry Co., Textron Inc.

564 FORBES AVE., PITTSBURGH 19, PA. • PLANTS AT GLASSPORT AND McKEESPORT, PA.



SCENE: One of the largest open hearth installations in the country.

DEEP DARK PLOT: Smoke abatement on a gigantic scale.

STELLAR CAST: Efficient electrostatic precipitators.

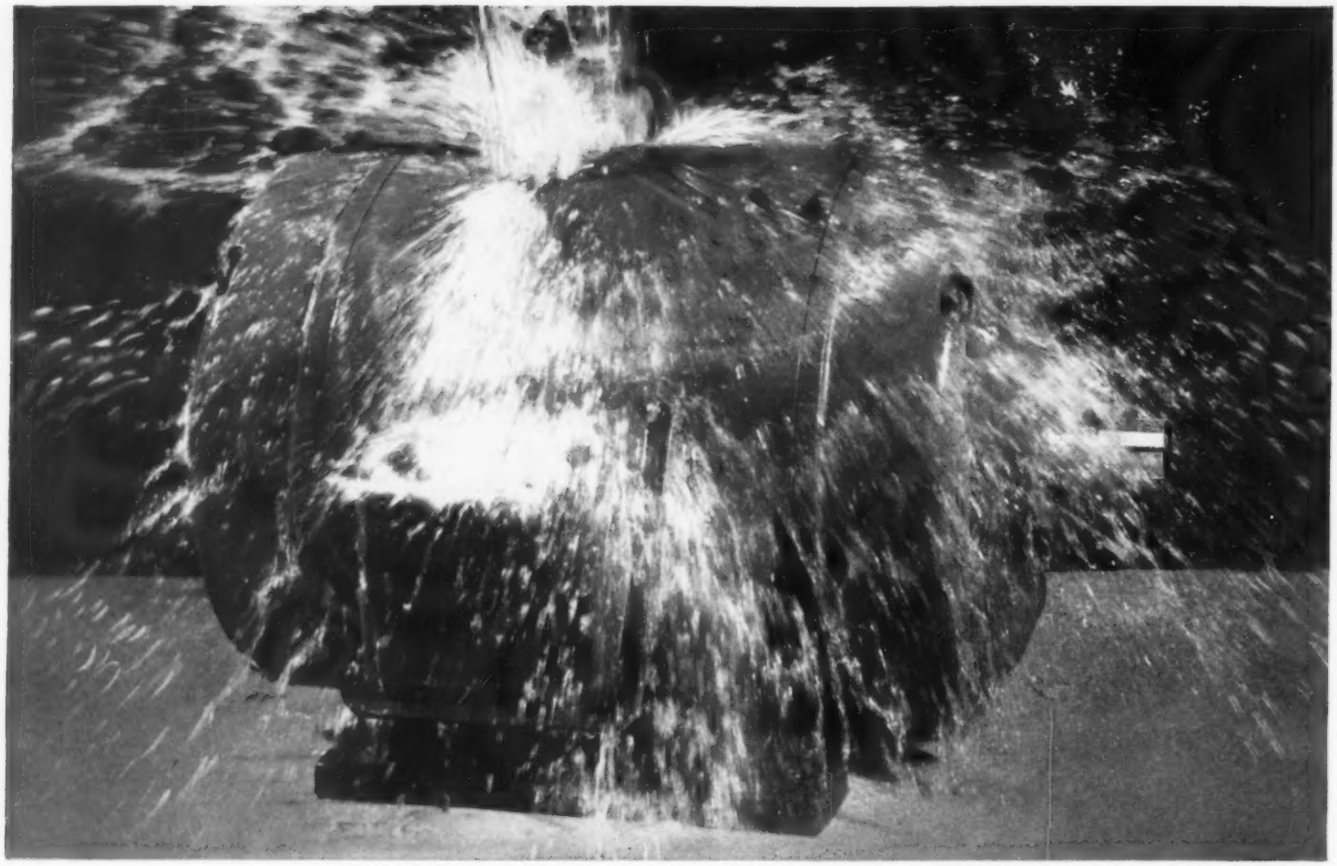
PRODUCER: Koppers—a leading manufacturer of gas cleaning equipment for industry.

**Facts available on request*

KOPPERS®

ELECTROSTATIC PRECIPITATORS

Engineered Products Sold with Service • Baltimore 3, Maryland



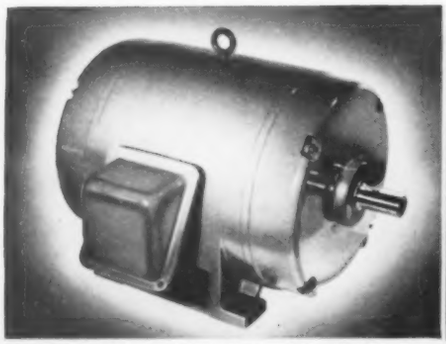
Sudden Splash or Soaking Shower

won't stop a Wagner® DP Motor . . .

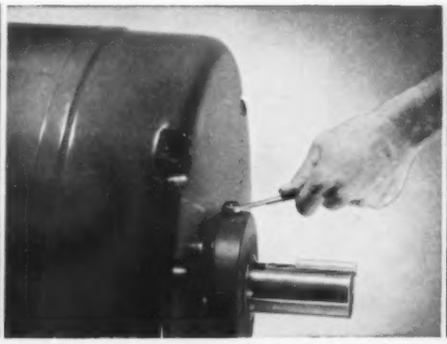
Wagner® Type DP Motors are doubly protected by rugged, corrosion-resistant cast iron frames and dripproof enclosures. Splashing or falling liquids, corrosive acids, salts, and alkalies can't stop their smooth operation. Designed to meet a wide variety of applications—including many that used to require splashproof motors—Wagner Doubly Protected Motors pack plenty of power into precious little space, are lightweight, long-lived, and pare downtime and upkeep costs to the bone. Simply put . . . they get the job done. Let your nearby Wagner Sales Engineer show you how these motors can be applied to your needs. Call him, or write for Bulletin MU-223.

Wagner Electric Corporation

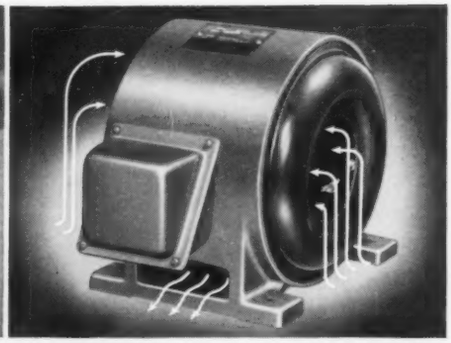
6483 PLYMOUTH AVE., ST. LOUIS 33, MISSOURI



SLEEVE BEARING MODELS AVAILABLE . . . DP Motors are built in NEMA frame sizes 182 through 445U; ½ through 125 hp—1750 RPM—40°C; available with ball bearing construction as illustrated or steel-backed, babbitt-lined sleeve bearings. Larger motors (Type RP) are available through 1000 hp.



CAN BE RELUBRICATED . . . Original factory lubrication will last for many years in normal service, but openings are provided to permit the relubrication that adds years to motor life under severe conditions.



COOL RUNNING . . . Specially designed baffles direct cooling air through the motor to reduce stator temperature, thus increasing motor life. Blowers, cast as part of the rotor, move large volumes of air without noise or vibration.

WM60-20

BLAW-KNOX

WIDE FLANGE BEAM and STRUCTURAL MILLS

Blaw-Knox designs and builds a full range of Wide Flange Beam and Structural Mills. Other Blaw-Knox equipment for the metals industry includes: Complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals • Sheet and strip processing equipment • Electrolytic tinning, annealing, and galvanizing lines • Seamless pipe and tube mills • Draw benches and cold draw equipment • Blaw-Knox Medart cold finishing equipment • Iron, alloy iron and steel rolls • Carbon and alloy steel castings • Fabricated steel plate or cast-weld design weldments • Steel plant equipment • Heat and corrosion resisting alloy castings. Blaw-Knox Company. Foundry and Mill Machinery Division. Blaw-Knox Building, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

Wide Flange Beam and Structural Mill at the South Works of the United States Steel Corporation

ELPAR'S New TITAN

. . . first BIG TRUCK with small truck maneuverability

No other truck in the 12,000 to 20,000 lb. capacity range can match the new TITAN for maneuverability. Built to operate through box car doors, the TITAN is ideal for car loading and for handling in narrow or congested aisles.

Other important features include:

TRI-SAFE BRAKING—an ELPAR safety exclusive that provides three independent braking systems operated by a single toe bar.

FASTER SPEEDS — fast lift and travel speeds plus rapid acceleration mean greater working efficiency.

UNEXCELLED VISION—elimination of bulky linkage gives the operator a clear view between the uprights.

As easy to operate as the family car, the new TITAN is the product of ELPAR's more than 50 years of industrial truck building experience. Compare features and you'll be convinced the TITAN is the best heavy duty fork truck buy!

5 models — 12,000 to 20,000 lbs. capacity

Send for this new TITAN folder —

ELPAR

ELECTRIC TRUCKS

THE **ELWELL-PARKER** ELECTRIC COMPANY
4549 ST. CLAIR AVENUE • CLEVELAND 3, OHIO
In Canada: International Equipment Company, Ltd.

TWICE THE LIFE . . . ONE-THIRD THE OPERATING COST

Femco, Inc.

MAIN OFFICE AND PLANT
IRWIN, PENNSYLVANIA
Telephone UNderhill 3-3200

Let's come down to earth
about Steel Plant automation.

Possibly the concept of a "completely automated steel plant" by 1970 is entirely correct. Even so, it will be many, many more years before the industry can afford to scrap its present facilities and spend the billions of dollars needed for enough dream plants to meet steel demand.

Meanwhile, steel men face the problem of getting more efficient production now.

FEMCO believes that the solution to this problem lies in a combination of automatic and remote control applied to present individual operations.

Automatic, because certain portions of the "work cycle" in many operations are repetitive, such as movement of a quench car from the oven to the quench tower and thence to the coke wharf.

Remote Control, because many portions of the work cycle must be varied to meet varying conditions. Human judgment is required - and remote control is the most efficient method of putting an operator's decisions into effect.

It has been our privilege to design and build many types of systems for many operations in steel plants of every size in the United States and abroad. These installations are convincing evidence that you share our confidence in this approach to your problem.

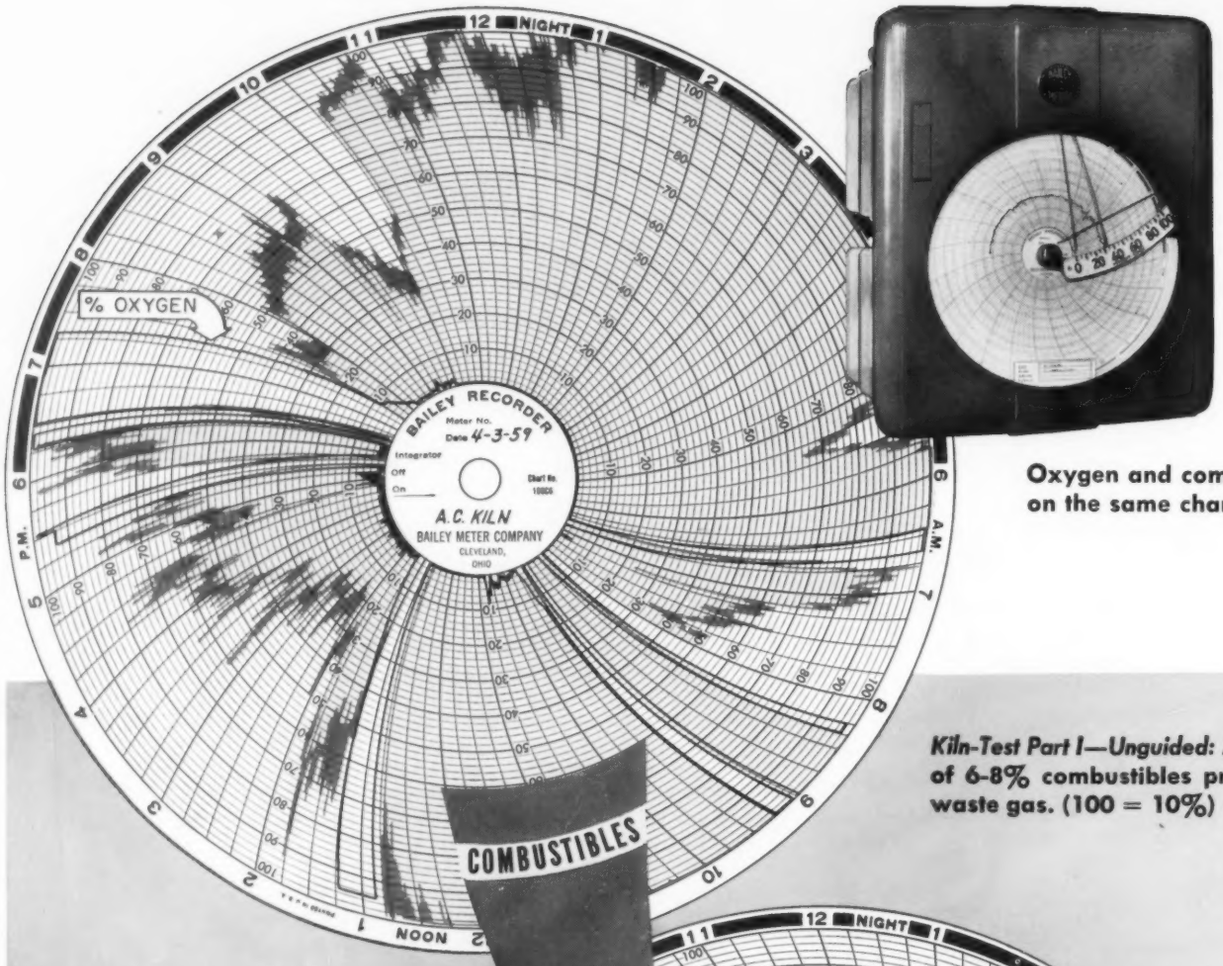
We will be glad to tell you about what we have already done for others - and we hope you will continue to challenge us with new problems in the future.

FEMCO, INC.

W. P. Place, President

COMMUNICATION • *Electronic Engineers* • AUTOMATION

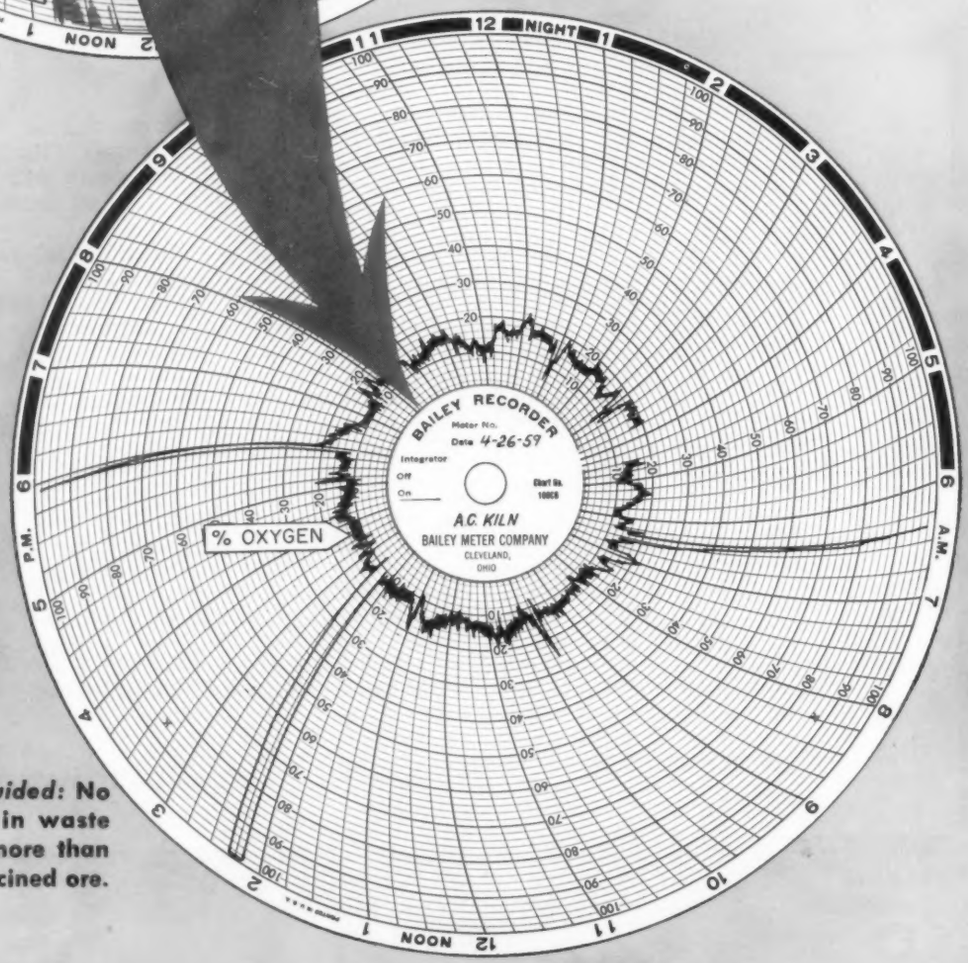
A-102



Oxygen and combustibles on the same chart.

Kiln-Test Part I—Unguided: **Average of 6-8% combustibles present in waste gas. (100 = 10%)**

COMBUSTIBLES



Kiln-Test Part II — Guided: **No combustibles present in waste gas. Fuel savings of more than 400,000 BTU/ton of calcined ore. (100 = 10%)**

Bailey's oxygen-combustibles recorder saves $50.00 per day for LONE STAR STEEL

The extent to which the Bailey Oxygen-Combustibles Recorder can help to improve operating economies at furnaces, hearths, and kilns was demonstrated recently at the Lone Star Steel Company, Lone Star, Texas.

Lone Star and Bailey Meter engineers conducted a five-week test, analyzing the waste gases from an Allis-Chalmers calcining kiln. For comparison, the test was conducted in two parts.

First, a Bailey Oxygen-Combustibles Recorder and a Bailey Analyzer were both located at the feed-end of the kiln . . . the burner could not observe the recorder. This gave a picture of regular operation.

Second, the Oxygen-Combustibles Recorder, shown top, left, was detached from the Analyzer Test Stand, and located at the firing end of the kiln. Now, at a single glance, the burner was able to determine the exact relationship between oxygen *and* combustibles.

RESULTS: During the first test period, as shown on the "unguided chart" at the left, an average of 6-8% combustibles was present in the waste gas.

During the second or guided phase of the test, shown on the chart at the left, *the high percentage of combustibles in the waste gas was completely eliminated*, while holding oxygen consistently between 1% to 2%.

This change represents a fuel saving of more than 400,000 BTU/ton of calcined ore . . . *more than $50.00 per day at this single kiln.* In terms of investment, this saving will pay for the Recorder and Analyzer units in less than 60 days.

Aside from this significant fuel saving, the ability to maintain the proper fuel-air ratio produced other benefits—*lower kiln and ore temperatures; sharply reduced ring formation within the kiln; lower maintenance costs; and operation at maximum capacity.*

If you operate open hearths, slab furnaces, soaking pits or other reheating furnaces, comparable benefits may be realized through the use of Bailey Oxygen-Combustible Recorders and Analyzers. Consult with your local Bailey engineer on your specific application. Or write to the Iron & Steel Division for more information. S115-2

IRON AND STEEL DIVISION

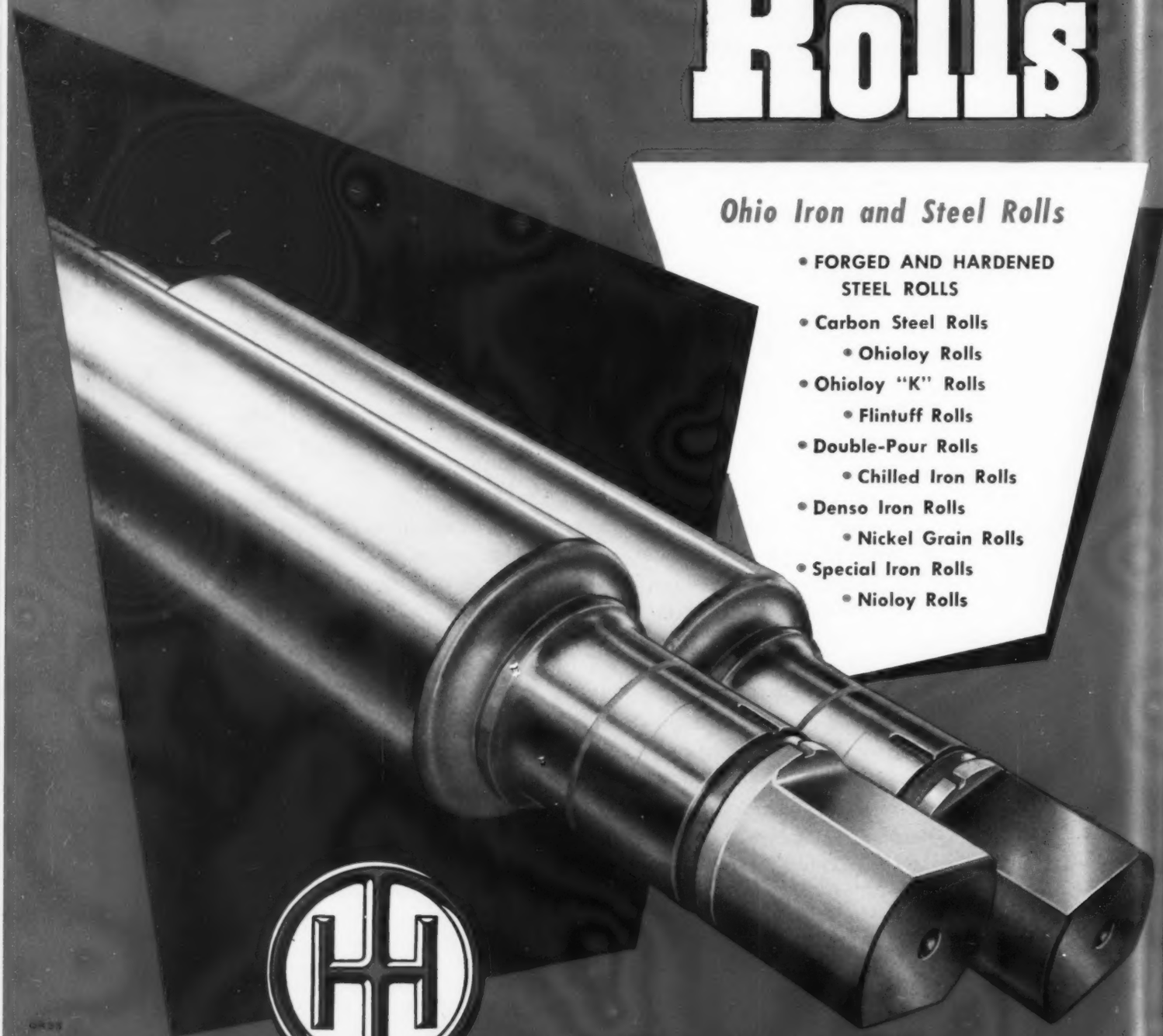
BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

Ohio Rolls

SHAPING METAL FOR ALL INDUSTRY



Ohio Iron and Steel Rolls

- FORGED AND HARDENED STEEL ROLLS
- Carbon Steel Rolls
- Ohioloy Rolls
- Ohioloy "K" Rolls
- Flintuff Rolls
- Double-Pour Rolls
- Chilled Iron Rolls
- Denso Iron Rolls
- Nickel Grain Rolls
- Special Iron Rolls
- Nioloy Rolls

THE OHIO STEEL FOUNDRY CO., LIMA, OHIO

PLANTS AT LIMA AND SPRINGFIELD, OHIO... *Virtually at the center of the steel industry*

Industry News...

CLAYMONT PLANT OF COLORADO FUEL & IRON IS PURCHASED BY PHOENIX STEEL CORP.

△ Phoenix Steel Corp. has purchased the Claymont steel plant located on the Delaware River at Claymont, Del., from The Colorado Fuel and Iron Corp., it was announced by A. F. Franz, president of Colorado Fuel and Iron, and J. A. Sisto, chairman of Phoenix Steel.

The Claymont plant has a rated annual ingot capacity of 506,500 tons. Prior to the sale, Colorado Fuel and Iron had an annual ingot capacity of 2,836,500 tons and Phoenix Steel had 846,760 tons.

Mr. Sisto said that "Phoenix's Chester blast furnace which is only three miles from Claymont was a key factor in the decision to purchase Claymont. The Claymont plant has no blast furnace. The use of the Chester blast furnace to supply hot metal to Claymont's open hearths will produce the quality and cost benefits of integrated steelmaking and make possible the adoption of new oxygen enrichment processes."

Commenting upon the transaction, Mr. Franz said, "The sale of Claymont will provide cash proceeds and release working capital which we believe can be put to work more profitably in improving and expanding our main plant at Pueblo, Colo. We have already embarked on an extensive modernization program at Pueblo which will provide new oxygen steelmaking facilities capable of producing over 600,000 tons of ingots annually to replace or expand older existing equipment."

Mr. Sisto pointed out that "The acquisition of Claymont will broaden Phoenix's product mix by the addition of several new specialty products, including stainless clad plate, alloy plate and electric weld pipe. The mill is located only 20 miles from Philadelphia and is ideally located to serve customers in the eastern market."

The Claymont property, which covers 725 acres, has over a mile of water-front on the Delaware River and ample acreage for future expansion. The plant has seven open hearth furnaces, two plate rolling mills of 160 and 120 in. widths, with a combined annual capacity of 300,000 tons, an electric weld mill for large diameter pipe, a well equipped fabricating shop, and a flanging, pressing and dished and spun head department.

ESSO BLAST FURNACE PROJECT ANNOUNCED

△ Esso Research and Engineering Co. revealed that for more than two years it has been conducting a concentrated program aimed at proving the feasibility of a 75-year-old ironmaking idea. The concept that has now been developed by scientific studies and experiments is that hydrocarbons, particularly heavy oil of high heat content, can be successfully injected into the bottom of blast furnaces and, in many circumstances, can increase capacity and decrease costs of "hot metal" production.

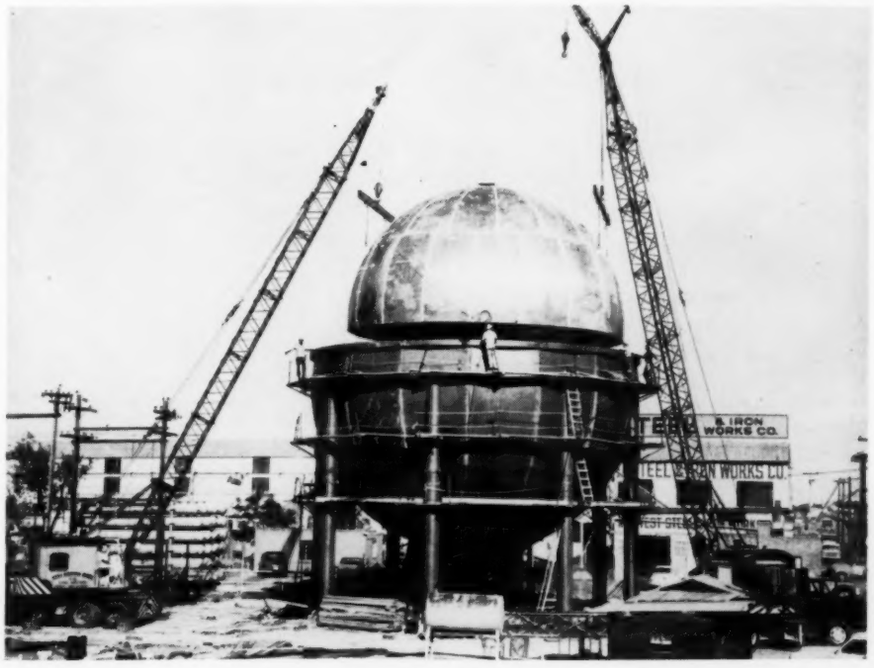
Esso Research investigated the practicality of the idea, and in an intensive program solved the complex problems involved and developed an injection and control system which makes the idea usable.

The scientific principles underlying the new development involve taking advantage of the chemical properties of oil as well as its heat-producing ability.

Blast furnaces produce pig iron in hot liquid form by extracting

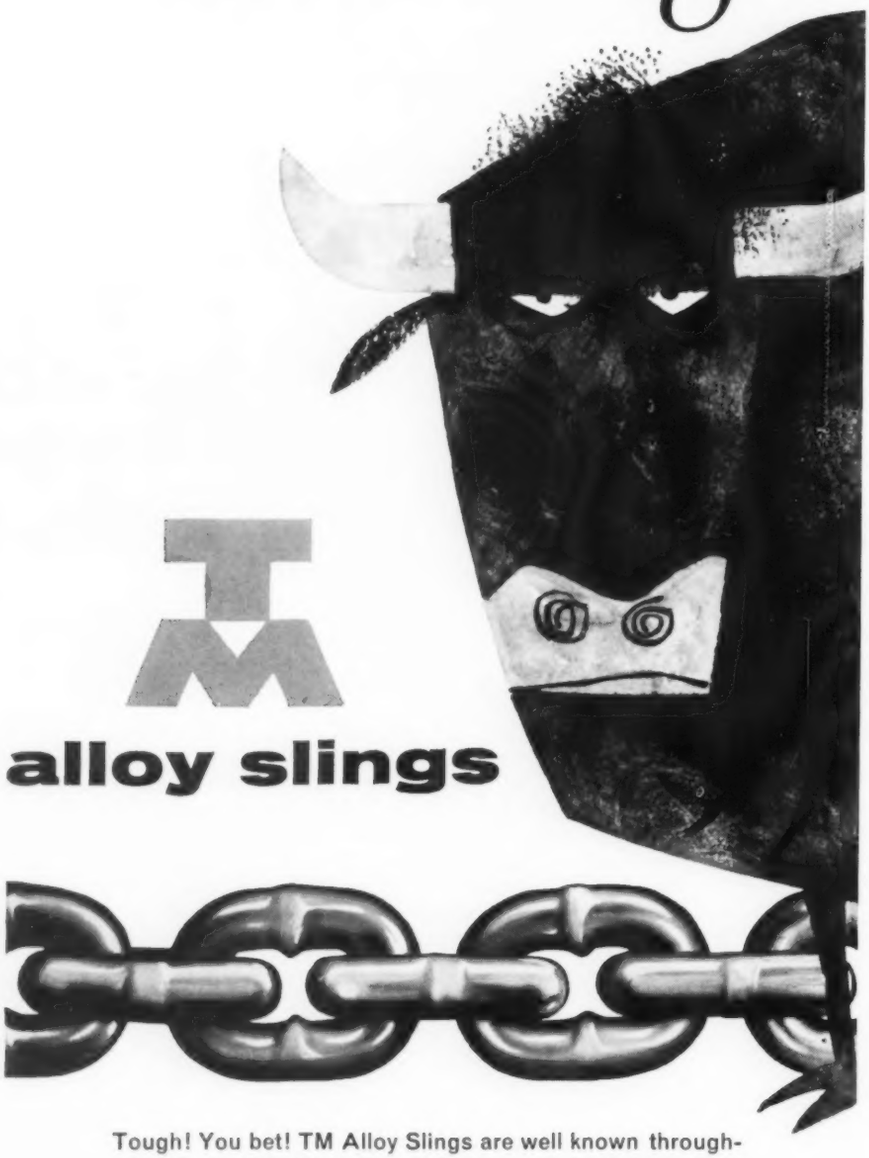
SPHERE WILL STORE OXYGEN AT PUEBLO PLANT

This 13-ton, specially-insulated sphere will store 25,000,000 cu ft of oxygen in liquid form at the super-cold temperature of −300 F at Colorado Fuel & Iron Corp.'s new on-site oxygen plant at Pueblo, Colo. Built by Linde Co., Division of Union Carbide Corp., the plant will supply more than 200,000,000 cu ft of oxygen per month for CF&I's mill operations and for two new oxygen converters also under construction. The converters will permit a 30 per cent boost in steel production when completed. The oxygen plant is scheduled for completion in March, 1961.



VALUED FOR

Brute Strength



TM alloy slings

Tough! You bet! TM Alloy Slings are well known throughout industry for plenty of muscle, low overall costs and that extra measure of safety. Taylor's safe, sure-grip Tayco Hooks and up-to-the-minute, *scientific*, quality control contribute to the brute strength of TM Alloy Slings. Factory-made to your specifications. Available nationally through industrial distributors, steel warehouses and hardware wholesalers. Write for Bulletin 14A.

Taylor Made CHAIN SINCE 1873

Prompt repairs on alloy slings in both plants.

S. G. TAYLOR CHAIN CO., Inc.
Plants: Hammond, Indiana
3505 Smallman St., Pittsburgh, Pa.

oxygen from iron oxide. The blast furnace is actually more of a chemical plant than a furnace, the company pointed out. Oil, which contains hydrogen, contributes additional "reducing" gas to speed the reduction of ore into iron.

Coke, iron ore and limestone are today fed into the top and hot air into the bottom of blast furnaces where temperatures reach some 3500 F.

With the new fueling method, oil can be injected along with the heated air. The petroleum fuel serves as part of the source of heat and of the "reducing" gases.

One of the most important Esso Research developments for this application of oil is the fuel injection and control system. Since blast furnaces "stay on the line" for as long as eight continuous years, this system must be so designed that it can be installed into large furnaces without any interruption in the use of the furnace.

In arriving at a suitable system, the company designed, built and operated a pilot plant simulating that part of a blast furnace most critical to oil injection. A unit of this system was later installed and tested in a hot operating large-scale furnace with complete success.

The company noted that some United States and European steel firms had been working along similar lines with natural gas injection, and that there are reports some Russian blast furnaces are using natural gas to increase their iron-making capacity.

The Esso Research study is still continuing on experimental and full-scale furnaces to get more accurate data on capacity increase and saving in operating costs.

BUILD NEW STAINLESS PLANT IN CALIFORNIA

△ A $5,000,000 stainless steel rolling mill, capable of producing 150,000 tons of rolled steel products yearly, will be built by New Pacific Rolling Mills, Inc., a newly formed division of the Consolidated New Pacific Industries, at Cucamonga, Calif. Contract for the job has been awarded to the McDowell-Wellman Co.

For

OXYGEN STEELMAKING PROCESSES

consult

WELLMAN

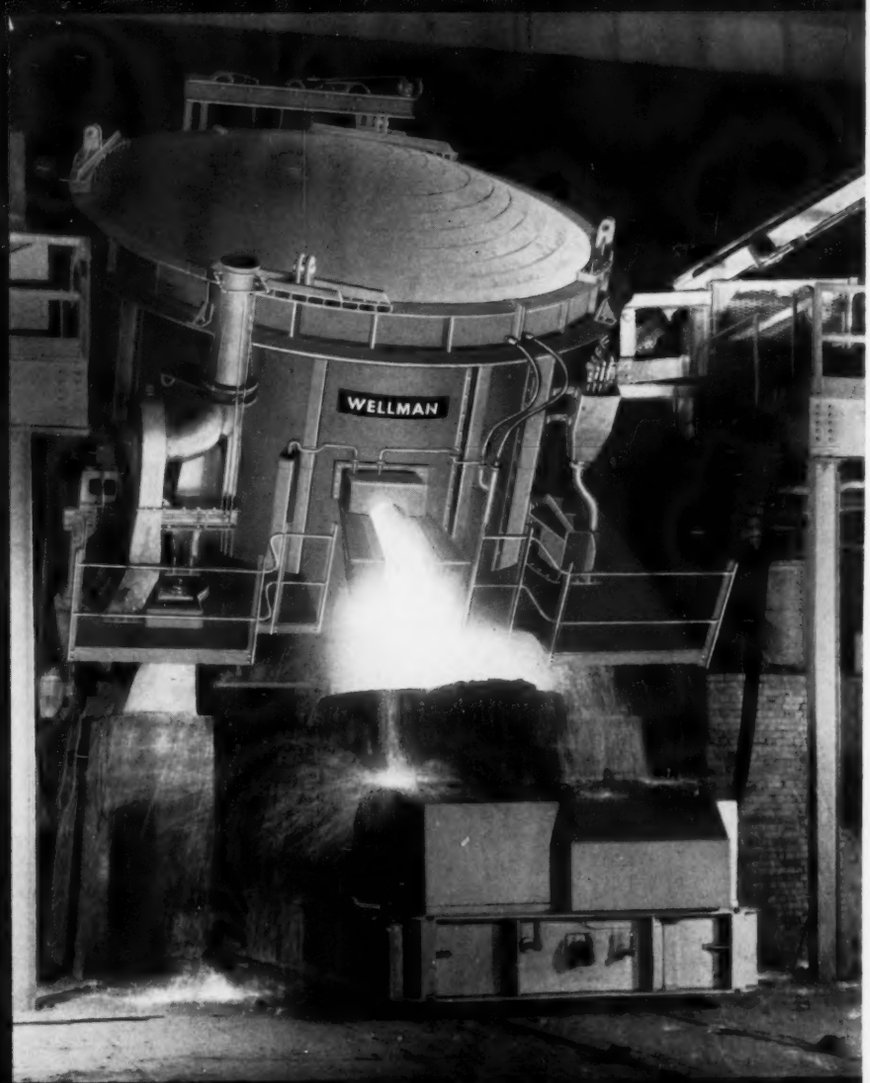
Marking a new departure in the practical field of oxygen steelmaking, this 20 ton unit for refining blast furnace metal was designed, in collaboration with the Brymbo Steel Works, and constructed by Wellman.

Refining is effected by injecting oxygen and powdered lime, through automatically controlled lances, into the bath.

The vessel has provision for:— slagging, adding scrap and fluxes, fettling, and sampling during operation.

This is a further example of Wellman activities in providing designs and equipment for new steelmaking techniques involving the use of tonnage oxygen.

BRITAIN'S *foremost builders of steelmaking plant*



THE WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD.

PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1 WORKS: DARLASTON, South Staffs, & BELFAST.

Another ⋈ Test System at work...

Magnatest eddy current unit, in which magnetic continuous weld pipe is tested for serious defects as it passes through sensing coils. Fully mechanized handling and automatic marking also provided by Magnaflux Corporation.

New Selective Eddy Current Test for Continuous Weld Pipe

This particular Magnatest SD-100 is one of a series of new Magnaflux-developed inspection systems for testing continuous butt-weld pipe and electric weld tubing. It precisely locates and marks the defects you want to find—at speeds to 600 feet per minute or more, on diameters up to 4".

The SD-100 is selective. It can be used to find varying degrees of gross defects. It will locate ring welds, caves, dents, scabs, saw cuts, slivers, burned welds, cold worked areas. Your needs are the determining factor . . . and with automatic marking and mechanized handling, available from Magnaflux, the per shift testing rates are determined mainly by your particular requirements.

Whether you test continuous butt-weld pipe or almost any other magnetic pipe, rod or wire, find out how one of the many ⋈ Test Systems can help you standardize quality and cut costs—per foot, per day or per 100 miles! Phone our local Magnaflux Field Engineer, or write Magnaflux Corporation, 7332 W. Lawrence Avenue, Chicago 31, Illinois.

MAGNAFLUX CORPORATION
A SUBSIDIARY OF GENERAL MILLS
General Mills
TEST SYSTEMS

MX Test Systems Include MAGNETIC PARTICLE, FLUORESCENT PENETRANT, THERMOGRAPHIC, EDDY CURRENT, ULTRASONIC, STRESS ANALYSIS, RADIOGRAPHIC TESTING, DYE PENETRANT & MAGNETIC FIELD

The plant is scheduled to be in production in the fall of 1961. It will employ about 125 persons initially, increasing to 250 as the plant reaches full production.

Situated on a four-acre site, the plant will occupy about 100,000 sq ft. It will consist of a continuous type merchant mill with three complete mills comprising several roll stands each.

J. N. Laughlin, manager of the plant and assistant to the president of New Pacific, said the mill will produce alloy and stainless steel bars, squares, flats, channel and angles, in sizes ranging from ¼ in. to 4 in. It will also make forging bullets of alloy and stainless steel to meet specifications of Western manufacturers. Plant facilities will include a modern laboratory and an engineering staff to help customers meet special needs.

The steel will be made by three electric furnaces, each capable of turning out 18 tons of hot metal per hour. The plant will buy some ore from West Coast sources but scrap metal will be its principal raw material.

ANNOUNCE COMPLETION OF NEW TINNING LINE

△ Completion of a third electrolytic tinning line has been announced at the East Chicago, Ind., plant of Inland Steel Co., which will increase its tinplate production 60 per cent and enable it to produce the metal in either coils or sheared lengths.

The new installation boosts Inland's tinplate production from 261,000 to 435,000 tons a year. It will put a tin coating on steel coils running continuously through the line at speeds as high as 1250 fpm.

The new line could also produce tinplate in cut lengths for customers who preferred their shipments in that form.

Unique inspection devices have been incorporated into the line. An x-ray coating weight gage automatically registers the thickness of tin on the steel sheets. An automatic data accumulation system has also been installed to record the characteristics of the tinplate and to detect any flaws.

The new line applies a light coating of tin to steel coils by electricity. As the coils are fed into the line they are threaded between tin anodes immersed in an acid bath, a process which results in the deposit of tin on the surface of the steel.

Before entering the line the steel is first reduced to the proper thickness on a cold reduction mill, softened and cleaned in an annealing furnace and restored to the desired resilience on a high speed temper mill. These steps enable the tin-coated metal to withstand forming operations in can manufacturers' plants.

A new continuous annealing furnace and a new high speed temper mill have also been completed by Inland to provide additional capacity for preparing the steel destined for the new tin mill.

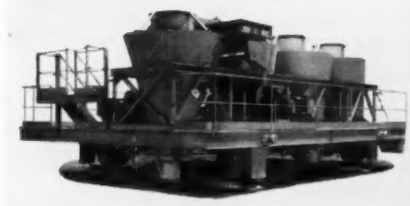
Inland will have an additional 130,000 tons of capacity to produce coiled tinplate next year when it completes the conversion of its No. 2 tinning line to coil instead of cut length production.

QUENCHER LOCOMOTIVE

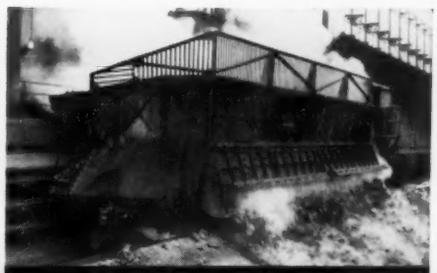
DOOR MACHINE

COKE
ON THE
MOVE

Operating economy and long life, again, are major advantages of Atlas equipment for highly specialized coke-producing service. Specially designed and ruggedly built to your exacting requirements.



COAL LARRY



COKE QUENCHING CAR

ATLAS CAR & MFG. COMPANY

Since 1896, Engineers-Builders of Ore Transfers...Scale Cars...Coke Quenchers...Coal Larries...Door Machines...Safety-Type Transfers ...Storage Battery Locomotives.

1140 IVANHOE ROAD • CLEVELAND 10, OHIO

. . . from start
YODER
. . . to finish
COLD ROLL-FORMING EQUIPMENT
PIPE AND TUBE MILLS (ferrous or non-ferrous)
ROTARY SLITTING LINES

YODER ROLL-FORMING EQUIPMENT

Profits are available to you through the production of many shapes in metal... made with precision and economy on Yoder Cold Roll Forming Equipment.

Produce tubular, ornamental or structural shapes from a variety of metals in widths from a fraction of an inch up to 80 inches or more, and in stock up to ¾" thick. Your investment is comparatively modest, and with proven low operating costs, will give you one of the most profitable operations in your plant.

Experienced Yoder engineers will, without obligation, study your annual metal forming requirements. Many times they can point out that the installation of roll forming equipment would—even if operated only intermittently—soon justify its initial cost.

Send today for this comprehensive, 88-page illustrated text. It fully describes Cold Roll Forming Equipment, processes and products.

THE YODER COMPANY
5495 Walworth Ave. • Cleveland 2, Ohio

ENGINEERING **YODER** MANUFACTURING

WIDE TV SCREEN

Operator in air-conditioned pulpit, overlooking rolling mill in Bethlehem Steel Co.'s Bethlehem, Pa., plant, watches TV screen which accurately measures a moving bloom as it passes through a downcut shear on its way to the roughing stands of the 42-in. mill. With the aid of the TV monitor, the shearman can cut the bloom in 12 to 36-ft lengths, within plus or minus 0.125 in.

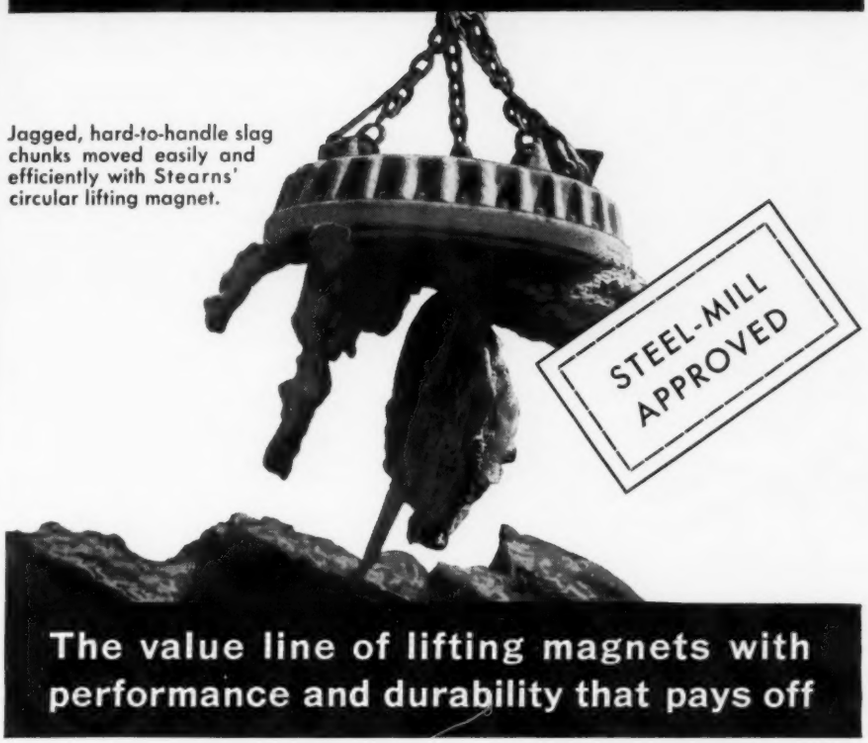
DE LAVAL ANNOUNCES TWO NEW DIVISIONS

△ De Laval Steam Turbine Co. has announced the establishment of two independent operating divisions, separating its larger custom-made products from its smaller standardized products. De Laval also announced the transfer of its Delroyd worm gear business to De Laval-Holroyd, Inc., an affiliate which it jointly owns with John Holroyd and Co., Ltd., Milnrow, Lancashire, England. The changes become effective January 1, 1961.

J. P. Stewart, president, said the move was made in recognition of the technical and sales differences between standard and custom products. He said the added independence for the two general types of products will better enable taking full advantage of opportunities for growth.

The new Machinery Division will design and manufacture De Laval's steam turbines, compressors, centrifugal pumps, marine gears, and other large products usually made to individual customer specifications. The Power Auxiliaries Division will initially include foun-

STEARNS lifting magnets CAN REALLY TAKE IT



Jagged, hard-to-handle slag chunks moved easily and efficiently with Stearns' circular lifting magnet.

The value line of lifting magnets with performance and durability that pays off

Stearns lifting magnets have become the standard of acceptance in the steel industry. The reason is simple — you can't buy better magnets at any price.

Check these advantage-features:

- **Cooler Operating** — deep-ribbed case.
- **Superior Perimeter Lifting Power** — new efficient field design.
- **Protection Against Shocks and Jars** — exclusive bronze "shock absorber" coil cover.
- **Waterproof Construction** — extra-close tolerances with heat-resistant gaskets.
- **Coil Life Safeguard** — automatically controlled oven-curing.
- **Protection Against Shorts, Leakage, Burnouts** — special laminated mica insulation.
- **Fully Protected Leads and Terminals** — recessed terminal box.

Standard circular or rectangular magnets are available in either bolted or all-welded styles, in a wide range of capacities and sizes:

Circular — 20" to 77" dia.
Rectangular — 9" x 24" to 26" x 80"

Whatever your steel-handling problem, Stearns engineers have the answer with built-in value.

Call in your local Stearns representative for a job-studied recommendation and price quotation, or write for Bulletin No. 35-C-J.

STEARNS MAGNETIC PRODUCTS

DIVISION OF INDIANA GENERAL CORPORATION • VALPARAISO, INDIANA

635 South 28th Street • Milwaukee 46, Wisconsin

Profit with Stearns — Pioneer Builder of Lifting Magnets

MR. RED CIRCLE

A Roll for Every Purpose

Our engineers will be glad to work with you in the production of any special rolls or rolling mill equipment.

Nickel Alloy Grain Rolls
Nickel Chilled Rolls
Grain Rolls
Chilled Rolls
Moly Rolls
Nodular Iron Rolls

Hyde Park Rolls have served J & L for years

Hyde Park
FOUNDRY AND MACHINE CO.
HYDE PARK
Westmoreland
County, Penna.

RC

Rolls
Rolling Mill Equipment
Gray Iron Castings

dry products and De Laval IMO pumps, and will act as a subcontractor to the Machinery Division for certain components for which its manufacturing facilities are better suited. Mr. Stewart said future expansion of this division is expected to include compatible products not now manufactured by De Laval.

The Machinery Division will be headed by Hans G. Bauer, executive vice president, who will also retain responsibility for district sales offices and sales representatives. Head of the Power Auxiliaries Division will be C. A. Jurgensen, vice president, who is also president of De Laval-Holroyd, Inc.

AWARDED CONTRACT FOR JAPANESE BAR MILL

△ Baldwin-Lima-Hamilton Corp. announced that Kobe Steel Works, Ltd., of Kobe, Japan, has signed a contract for a steel rolling mill with the corporation's Industrial Equipment Division.

The equipment, a modern continuous merchant bar mill which incorporates the latest rolling mill techniques, will be installed at Kobe. The mill will have a production capacity of 25,000 tons per month.

The steel manufacturing installation at Kobe, which will cost more than $10,000,000, will provide maximum flexibility and automation for fabricating round and square bars, angles, channels and other steel products.

CHANGE DIVISION NAME TO TRW COMPUTERS CO.

△ TRW Computers Co. has been announced as the new name for The Thompson-Ramo-Wooldridge Products Co. The company will continue to function as a computer division of Thompson Ramo Wooldridge Inc. Headquarters will remain in Beverly Hills, Calif.

"The change in name is being made to emphasize our affiliation with TRW and to reflect more definitely the nature of our business activities," Dr. Joseph F. Manildi, general manager of the division, explained.

"Our scope of activity in the field of computer control has broadened as we have developed new computer applications," Dr. Manildi said, "and a new name has become desirable to describe our broader interests in this expanding field."

TRW Computers will continue to market the RW-300 Digital Control Computer which was introduced in 1957 as the world's first computer designed and engineered specifically for automatic control of industrial processes.

In general, TRW Computers will assume the responsibility in the commercial field for marketing, applications engineering, installation engineering, programming, and maintenance of digital equipment developed by the Ramo-Wooldridge Division. Sale of large developmental systems to military agencies will continue to be the responsibility of the Ramo-Wooldridge Division.

NEW REPRESENTATIVE APPOINTED BY DREVER

△ Warren H. Neville announces that this company the NEVCO Corp., Riverside, Calif., is now the west coast engineering representative for the Drever Corp. NEVCO also represents Fennell Corp., H-Hard Roll Corp., Illinois Clay Products Co., Kozma Co., M & G Industrial Associates and the Tate-Jones Co., and is able to provide a complete service in the industrial heating and process field.

Mr. Neville was formerly sales and project engineer with the Swindell-Dressler Corp.

ORDERS STANAT MILLS FOR RESEARCH CENTER

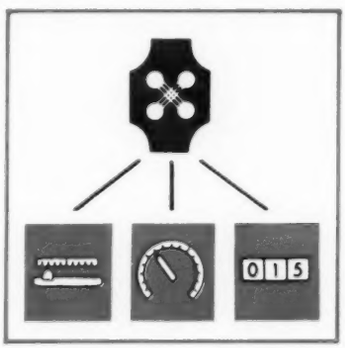
△ Receipt of an order from Armco Steel Corp. for a hot reversing mill and cold strip mill to be installed at the Armco Research Center in Middletown, Ohio, has been announced by Stanat Manufacturing Co., Inc. The order, which amounts to about $150,000 is scheduled for completion in March, 1961.

The hot mill will include provision for rapid reversal and reduction of hot billets which will subsequently be reduced to strip and coiled under tension in the 2-high/4-high cold mill. Both mills will be powered by highly refined d-c drive systems including motorized screwdowns.

(*Please turn to page 192*)

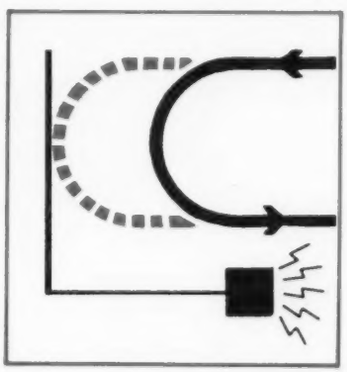
ASEA control equipment for steel mills

PRESSDUCTOR – for measurement of roll separating force in mills, strip tension, crane and conveyor weighing. The pressductor is a reliable load cell with high output and low impedance, specially designed for the rough environment encountered in heavy industry throughout the entire world.



TORDUCTOR – for torque measurement. This is a very compact torque gauge, working without mechanical contact with the shaft. The torductor is accurate and reliable and is available for all shaft sizes starting from 3 in. diameter and up. Output is high enough to feed instruments and recorders directly without need of amplification.

LOOP REGULATOR – for loop regulation in hot rolling mills for wire and strip. This is a photo-electric regulator, not in physical contact with the loop. The regulator produces a DC voltage which continuously increases as the loop moves from its correct position. The movement of the source of radiation from one extremity to the other changes the output voltage from maximum positive through zero at correct position, to maximum negative polarity.

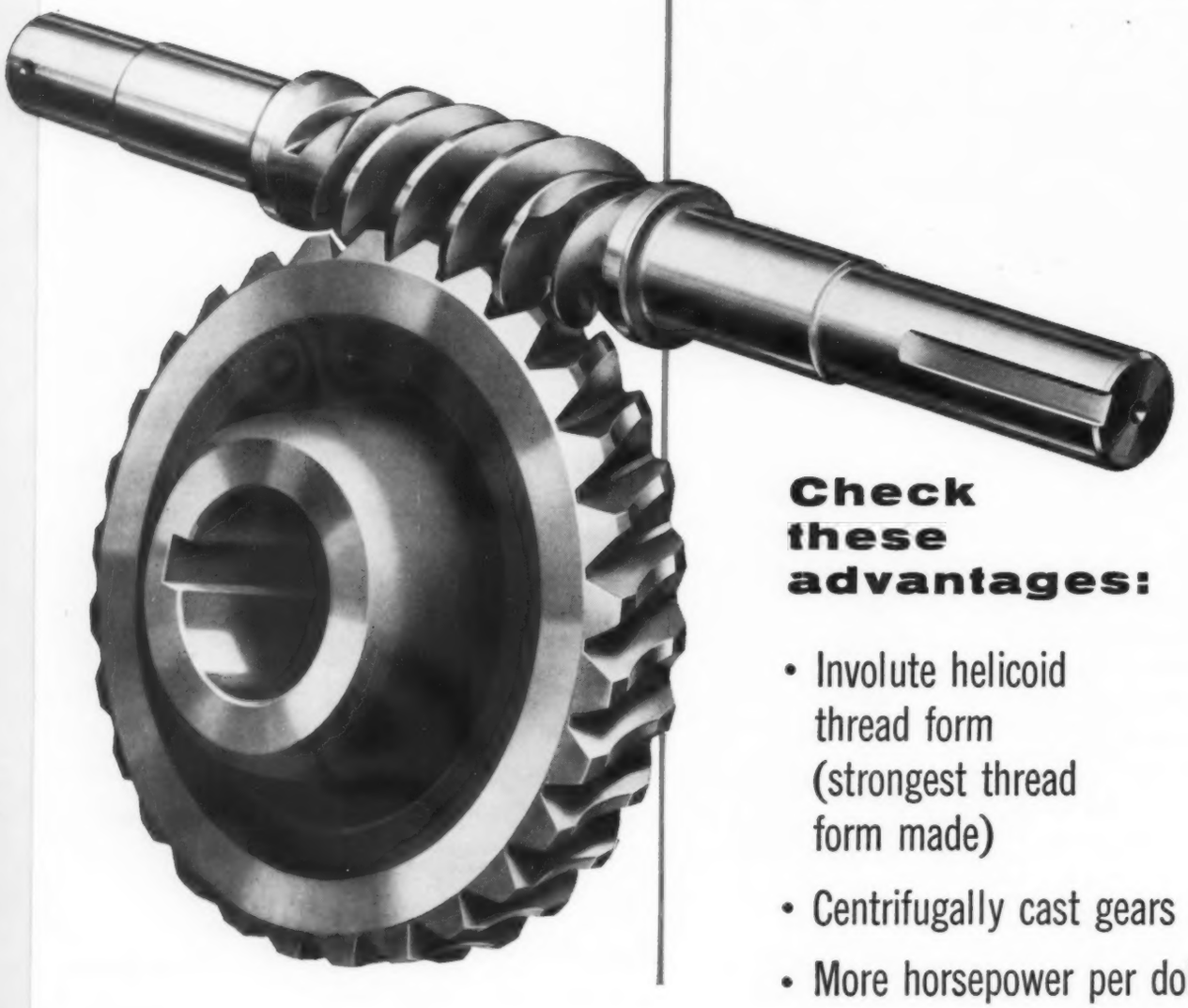


ASEA controls are widely used by industry around the world. For full information and leaflets write to: ASEA ELECTRIC INC. 500 - 5th Avenue, New York 36, New York 55 New Montgomery St. San Francisco 5, Cal.

ASEA

DELROYD

WORM GEAR SETS



Check these advantages:

- Involute helicoid thread form (strongest thread form made)
- Centrifugally cast gears
- More horsepower per dollar

Delroyd units are manufactured in a modern plant devoted specifically to the production of worm gearing—a plant which has one of the largest thread milling and thread grinding capacities in the United States. Because we use this exclusive precision machinery, the most exacting testing techniques and highly skilled workmanship, you are assured of quality and service associated with the leading specialists in worm gearing.

Delroyd provides the widest range of sizes and ratios, and offers complete interchangeability of parts. Whether you specify worm gear sets or worm gear speed reducers, you are assured of the finest quality obtainable.

Write for Bulletin 3800

DE LAVAL *Steam Turbine Company*

870 NOTTINGHAM WAY, TRENTON 2, N. J.

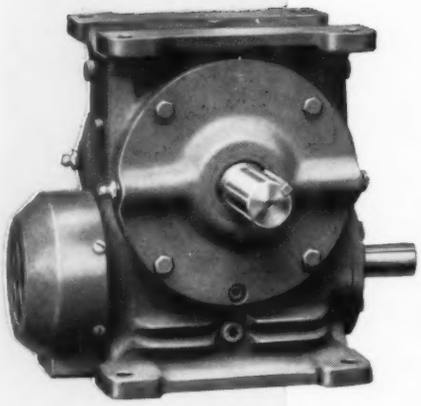
DELROYD

WORM GEAR SPEED REDUCERS

FAN COOLED RIBBED CASES

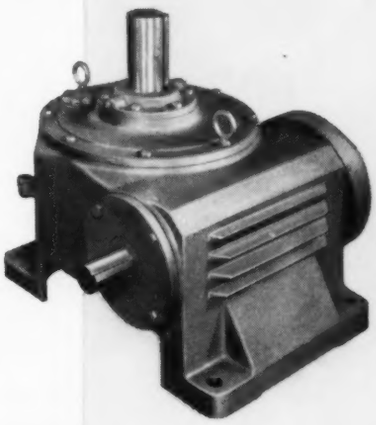
Widest range of ratings available—from .05 HP, 1⅛" center distance to 1050 HP, 36" center distance—in single and double reduction units

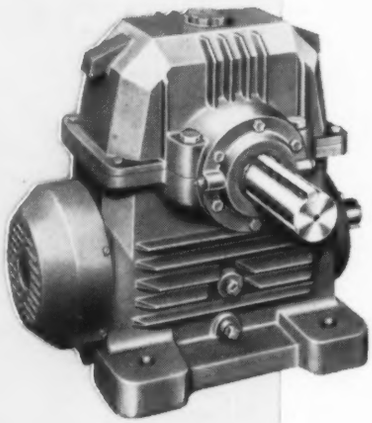
Prompt delivery from stock—all units through 12 inch center distance



TYPE D
Verso Unit
Adapts to any mounting requirement
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 13.5
Center distance:
2½" to 4"

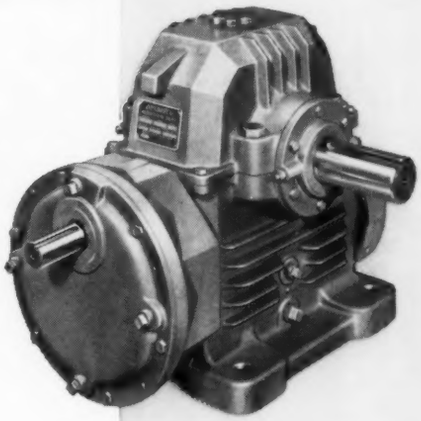
TYPE V
Vertical single reduction
Shaft up or down
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

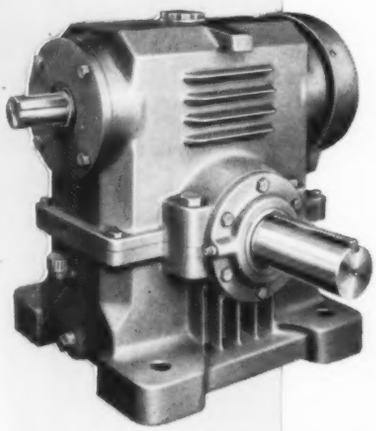




TYPE B
Horizontal single reduction
Bottom drive
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

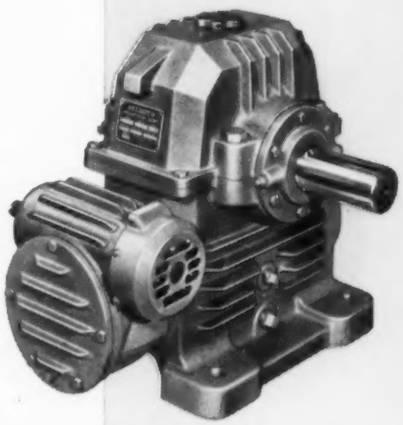
TYPE HB
Horizontal helical-worm
Right angle drive
Ratios:
15:1 to 355:1
Output torque:
2460 in. lbs. to 135000 in. lbs.
Center distance:
3½" to 12"





TYPE T
Horizontal single reduction
Top drive
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

TYPE DB
Horizontal double-worm
Parallel input and output shafts
Ratios:
75:1 to 4900:1
Output torque:
4170 in. lbs. to 135000 in. lbs.
Center distance:
3½" to 12"



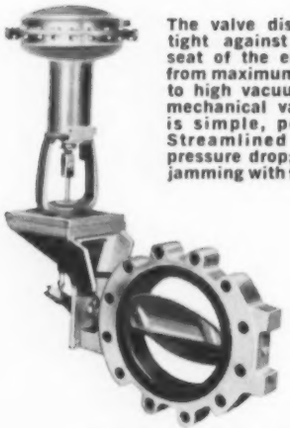
Write for Bulletin 3810

DE LAVAL *Steam Turbine Company*

870 NOTTINGHAM WAY, TRENTON 2, N. J.

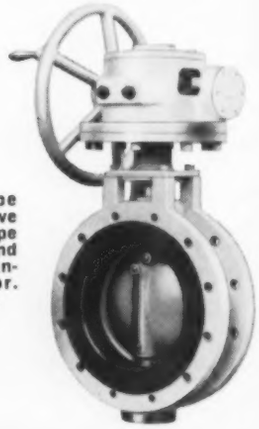
DL-428

TIGHT CLOSURE is NO PROBLEM with ROCKWELL BUTTERFLY VALVES



The valve disc seats drop-tight against the resilient seat of the elastomer liner from maximum line pressure to high vacuum. Manual or mechanical valve operation is simple, positive, fast. Streamlined design; low pressure drop; no fouling or jamming with foreign matter.

Wafer type butterfly valve with spool type rubber liner, available in "Keelok" snap-in, easily replaceable type or vulcanized to body. Shown with pneumatic operator. Bulletin 583.



Flanged type butterfly valve with spool type rubber liner and worm gear manual operator. Bulletin 582.

W. S. ROCKWELL CO.

2360 ELIOT ST. FAIRFIELD, CONN.

(*Continued from page 188*)

The cold mill will feature a unique, hydraulically operated collapsing mandrel and coil stripping arrangement to facilitate coil handling.

LICENSE JAPANESE FIRM TO BUILD OXYGEN UNITS

△ Pennsylvania Engineering Corp. has signed a second license agreement arranging for the manufacture of its basic oxygen converters in foreign countries.

Kawasaki Dockyard Co., Inc., of Kobe, Japan, has been licensed to manufacture PECor oxygen converters and auxiliaries for installation in Japan, South Korea, Nationalist China, South Viet-Nam, Thailand, Indonesia, Burma and the Philippines. Kawasaki Dockyard Co. is one of Japan's largest producers of ships, marine engines, thermal power plants, chemical processing equipment and steelmaking machinery.

Pennsylvania Engineering recently announced an agreement with a British firm, Ashmore, Benson, Pease & Co. Ltd., providing for the manufacture of PECor-designed oxygen converters in the United Kingdom, Europe, Australia and South Africa.

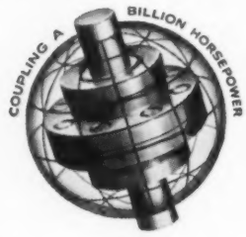
The agreement with Kawasaki involves providing technical data, engineering, drawings and specifications necessary for making proposals and building the converters, as well as for training of some Kawasaki employees in Pennsylvania Engineering's plant.

EATON APPOINTS NEW DETROIT REPRESENTATIVE

△ The Cleveland Worm & Gear and Farval Divisions of Eaton Manufacturing Co. announced the appointment of the J. R. Dunlop Co. as sales representatives in the Detroit, Mich., area for the complete line of products of the two divisions.

The company was formed recently by Jack Dunlop who, for the past 10 years, had been associated with the Jesse W. Eakins Co., Eaton's former representatives. Associated with Mr. Dunlop will be T. A. Shannon, formerly a field engineer for 14 years with the Farval Division in the Detroit area.

WHEN YOU NEED HELP IN A HURRY—



Koppers coupling service cuts costly down-time

Not every coupling service need is an emergency. But it's the emergencies that really test a good organization. That's why Koppers maintains experienced field engineers and outstanding stock facilities throughout the country. In addition, if it's a Fast's Coupling you're replacing, we have a serial number and specific application history for every Fast's for easy reordering. And our modern manufacturing facilities have the extra capacity to lick an emergency for special requirements.

Example: A modern windowless bank in Georgia was able to open for business as usual only because Koppers flew in a completed replacement coupling for its air conditioning unit. Elapsed time . . . request phoned to Baltimore after 10 in the evening . . . coupling arrived before 7:30 next morning.

KOPPERS COMPANY, INC., 111 Scott St., Baltimore 3, Md.

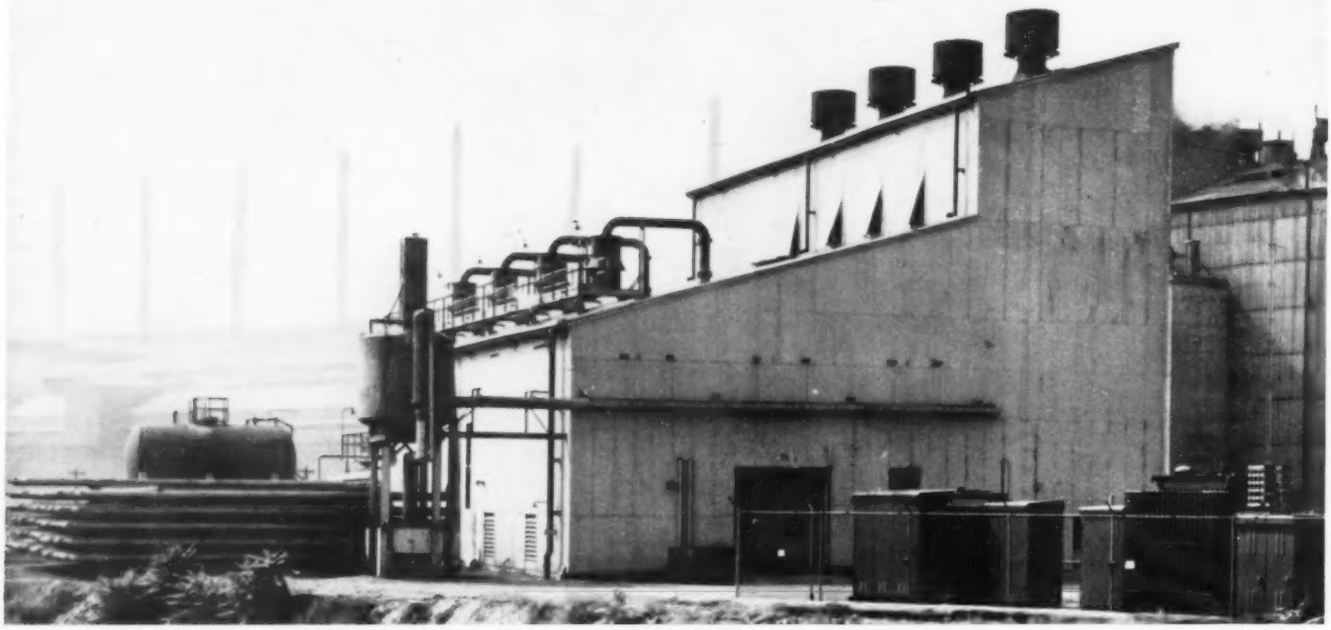
KOPPERS

FAST'S COUPLINGS

Engineered Products Sold with Service

MORGAN
WORCESTER
4-STRAND
ROD MILL
American Steel & Wire Division, United States Steel Corp.
CUYAHOGA WORKS, CLEVELAND, OHIO
Rolling tonnage records
such as an average of 551 tons per eight hour turn
for 83 consecutive turns.
MORGAN CONSTRUCTION COMPANY
WORCESTER, MASS.
ROLLING MILLS • MORGOIL BEARINGS • WIRE MACHINERY • REGENERATIVE FURNACE CONTROL • EJECTORS • GAS PRODUCERS

BRISTOL TELEMETERS RECORD OXYGEN DISPATCHING AT JONES & LAUGHLIN STEEL



Oxygen plant at Jones & Laughlin's Pittsburgh Works. Approximately 69,000,000 cubic feet per month of high purity O_2 are generated here and dispatched by Bristol Metameter* Telemeters to serve the 295-acre works (background).

Miniature strip chart instruments simplify central O_2 dispatching throughout 295-acre Pittsburgh Works

Miniature Bristol Metameter* instruments give the central dispatcher all the information he needs for efficient, economical, oxygen dispatching at the 295-acre Pittsburgh Works Division of Jones & Laughlin Steel.

Among the functions recorded are plant line oxygen pressure, oxygen consumption for billet scarfing, slab mechanical scarfing and blast furnaces, total oxygen consumption for plant, and cubic feet of oxygen storage at standard conditions. The dispatching system has proved entirely satisfactory and capable of meeting emergency conditions.

This is typical of the service Bristol instrument systems are rendering in today's steel plants. They can help you step up production, increase product uniformity, save fuel costs, and release valuable supervisory time for more important duties. They measure, indicate, record, or automatically control a tremendous variety of variables. Just a few of these are: oxygen pressure and flow (current rate and total), oxygen lance position, lance cooling water temperature, fuel flow and pressure (coke-oven gas, natural gas, oil)—as well as complete telemetering and dispatching center instrumentation for both fuel and oxygen pipelines—and electrical quantities: voltage, current, power and resistance.

Why not learn more about Bristol instruments for your steel plant application? Bristol application engineers will be glad to talk over your specific problems. Or, we'll send you data on Bristol instruments for any specific application. Write: The Bristol Company, 123 Bristol Road, Waterbury 20, Connecticut. O.31

*T. M. Reg. U. S. Pat. Off.

Bristol Instrument Panel at Jones & Laughlin Steel's Pittsburgh Works. One section records oxygen flows and pressures, while the remaining two sections record fuel gas flows and pressures. Flow integration is provided on a separate panel not shown.

BRISTOL... for improved production through measurement and control
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Joe Zimmermann shown with one of four 36" x 48" Main Bridle Rolls especially designed for uptake bridle at end of a new continuous annealing line. These rolls were covered with SPEC. GL 5-RM 110 material. This type of roll covering lasts 5 times longer than the best grade rubber type covering, with less maintenance and down-time. They also eliminate pick-up and the scratching of strip. For the answers to your problems with steel rolls—call:

JOSEPH ZIMMERMANN, PRES.

STEEL PLANT EQUIPMENT CORP.

Wilson Blvd. & Ridge Pike, Eagleville, Pa. phone BR 5-7539

They say PROVINCIAL Engineering Ltd. builds the finest cranes in Canada

Yeah-And they'll be building them in the year 2000!

Hammerlok®
COUPLING LINK

MAKE UP YOUR OWN HERC-ALLOY SLINGS. No more waiting for new or repaired assemblies to reach you from the factory.

- No peening or welding
- Anybody can assemble
- Stronger than Herc-Alloy chain
- Thoroughly field tested
- Re-useable and SAFE

Write for Bulletin and name of your CM Distributor stocking Herc-Alloy chain, master links, hooks and Hammerlok coupling links.

CM CHAIN

COLUMBUS McKINNON CHAIN CORP.
TONAWANDA, NEW YORK
NEW YORK • CHICAGO • CLEVELAND
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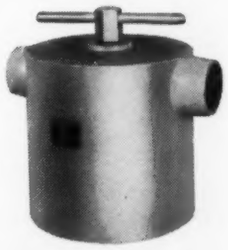
In Canada: McKinnon Columbus Chain Ltd., St. Catharines, Ont.
HERC-ALLOY®

Frantz **FERROFILTER** Magnetic Separators will keep your rolls rolling longer by keeping lubricating oil free from ferrous grit—rust, scale, core sand, and steel particles worn off moving parts. They help prevent excessive wear of roll neck bearings and reduce costly shutdowns and maintenance time.

FERROFILTER®

MAGNETIC SEPARATORS



Right: Model **PQ-6 FERROFILTER** for 3" pipe made this way or with flanged pipe connections. Others for 3/8" to 8" pipe.

Write for Bulletin

S. G. FRANTZ CO., INC.
4411 Kline Ave. at Brunswick Pike
P. O. Box 1138 Trenton 6, N.J.

Now SKF has improved the spherical roller bearing it invented!

This new spherical roller bearing offers even higher capacity than SKF's original, self-aligning bearing – and meets the needs of today's faster, more productive machinery. In some cases, the increase in capacity is as much as 54% – corresponding to more than 4 times longer service life!

Here's how these improvements have been obtained:

1. Eliminating undercuts and integral flanges – helps provide space for larger rollers and longer effective contact between rollers and races.

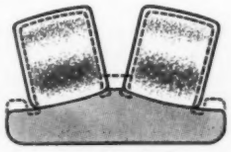


Fig. 1

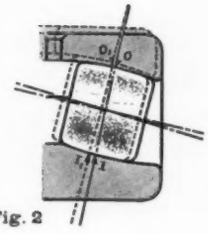


Fig. 2

2. Using symmetrical rollers, unrestricted by flanges – ensures uniform load distribution over the roller length at all times, even under heavy thrust load.

3. Using an axially floating guide ring – provides effective roller guiding, and minimizes friction at roller ends.

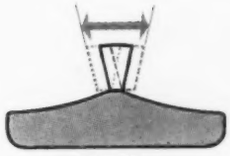


Fig. 3

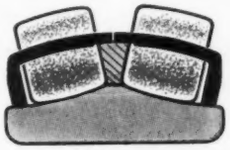


Fig. 4

4. Using a strong "window-type" cage for each row of rollers—helps ensure dependable operation over a full range of loads and speeds.

5. Placing a lubricant duct in the center of the outer ring—helps channel lubricants directly to the rollers and push contaminants away.

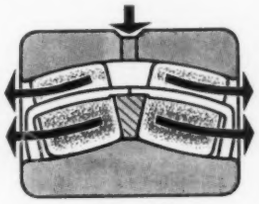


Fig. 5

For full details on this new high-capacity spherical roller bearing call the nearest SKF sales office or authorized SKF distributor listed in the yellow pages of the telephone book.

5931

Spherical, Cylindrical, Ball, and Tyson *Tapered Roller Bearings*

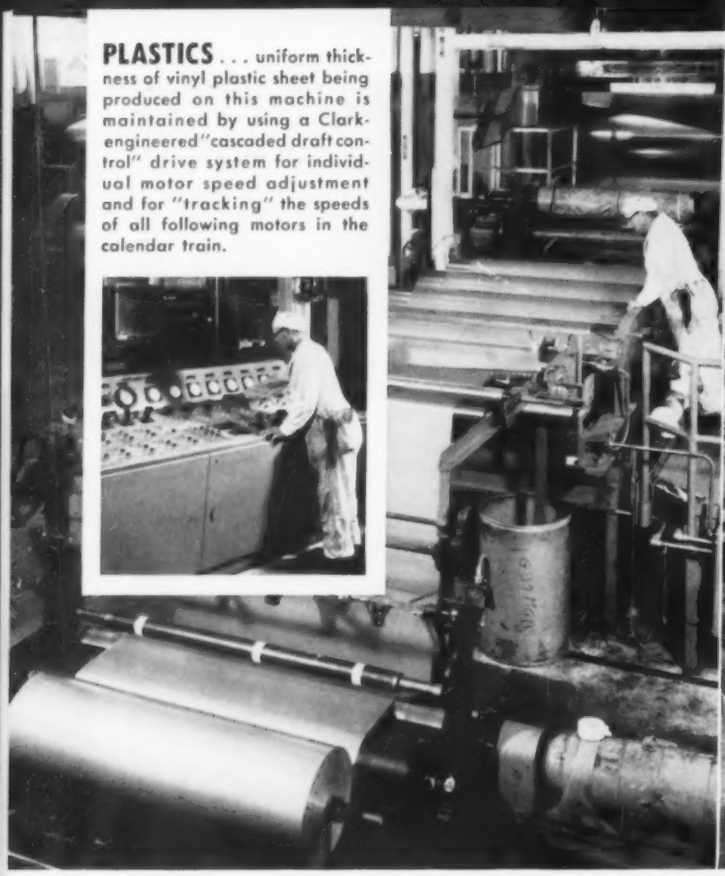
EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

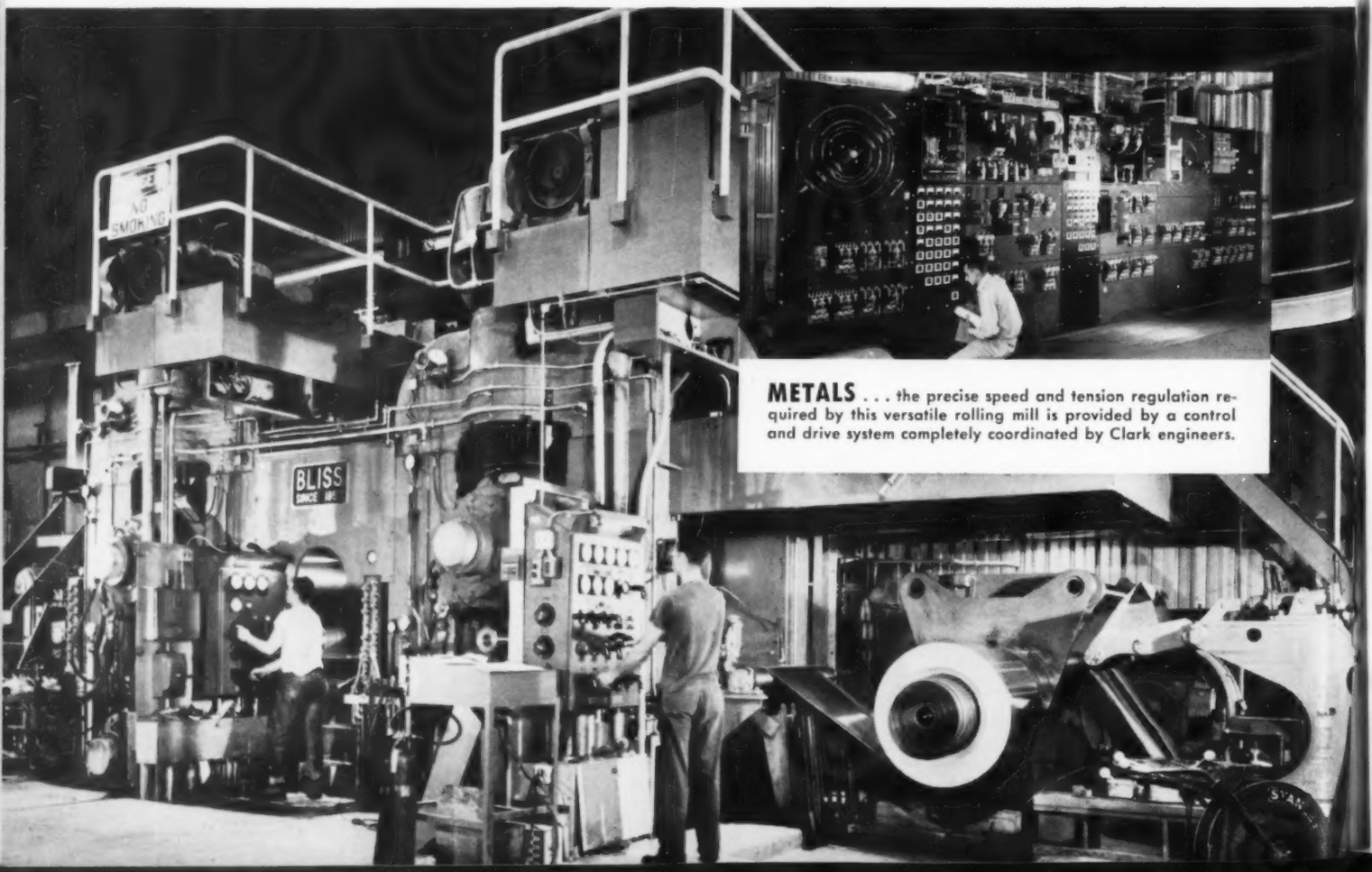
*REG. U. S. PAT. OFF.

PLASTICS . . . uniform thickness of vinyl plastic sheet being produced on this machine is maintained by using a Clark-engineered "cascaded draft control" drive system for individual motor speed adjustment and for "tracking" the speeds of all following motors in the calendar train.

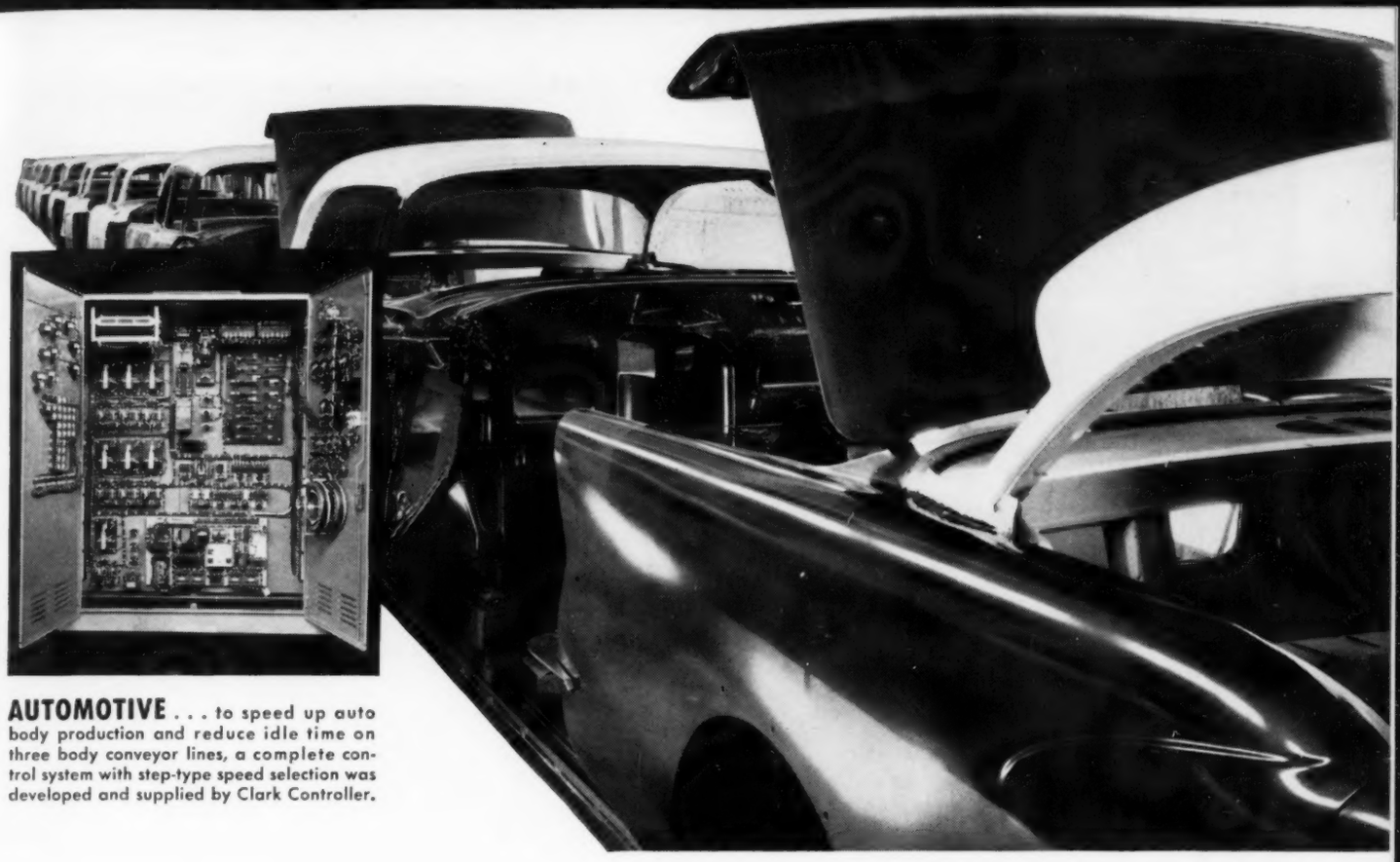


FOODS . . . automated transfer of bulk sugar from ships to warehouses at rates up to 300 tons per hour is directed by a Clark-engineered and Clark-built control system.

How to get the most from



METALS . . . the precise speed and tension regulation required by this versatile rolling mill is provided by a control and drive system completely coordinated by Clark engineers.



AUTOMOTIVE . . . to speed up auto body production and reduce idle time on three body conveyor lines, a complete control system with step-type speed selection was developed and supplied by Clark Controller.

your machines and processes

Automatic control is the most vital element in today's automated processes, systems and machines.

Clark engineers are specialists in automatic controls, and Clark's control equipment—relays, contactors, push buttons, control centers, etc.—is designed with a thorough knowledge of specific industry requirements.

Clark is therefore ideally qualified to furnish complete coordinated control and drive systems.

Perhaps this great combination of product and experience can help you directly. It makes no difference what industry or type of production machinery or process. More and more automation-minded manufacturers everywhere are turning to Clark for completely coordinated control engineering service and equipment.

From concept to start-up, Clark engineers work as partners with engineering and manufacturing personnel, consulting engineers, contractors, and equipment manufacturers. We welcome the opportunity to show you how they can work for your particular advantage. For more information, contact your nearest Clark Controller sales office. Or, write direct.

60 A1

The
CLARK CONTROLLER
Company

"Everything Under Control"

Main Plant: *Cleveland 10* • **Western Plant:** *Los Angeles 58*
In Canada: *Canadian Controllers, Limited, Toronto*

Positive bin level control— no overflows...no empties

with

STEPHENS-ADAMSON

"TELLEVEL"®

BIN-LEVEL CONTROLS

- Normal Duty Model for controlling flow of light to medium weight granular material.
- Pendant float-ball or float-cone operates sensitive switch to regulate level of bulk materials.
- Installed at various bin levels, the unit will start or stop flow of materials or operate signal light or horn automatically.

AVAILABLE IN THREE MODELS

- Normal Duty
- Explosion-Proof
- Heavy Duty

S-A

WRITE FOR BULLETIN 159

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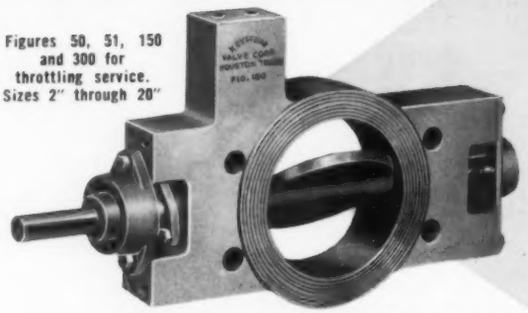
PLANTS LOCATED IN: LOS ANGELES, CALIFORNIA
CLARKSDALE, MISSISSIPPI • BELLEVILLE, ONTARIO

KEYSTONE SWING-THROUGH or THROTTLING VALVES

Figures 50, 51, 150 and 300 for throttling service. Sizes 2" through 20"



Figures 51, 150 and 300 with Ball Bearings

FIGURES 50 AND 51 feature two packing glands, one piece shaft, positive alignment with the piping. Operated manually or automatically. Designed for 50 lb. pressure drop in the closed position. FIGURES 150 AND 300 are heavy pattern valves, constructed for long trouble-free life, featuring two outboard anti-friction bearings plus two bronze inboard bearings. Designed for a 150 lb. and 300 lb. pressure drop at the closed position. Keystone also manufactures a complete line of Replaceable Resilient seated valves.

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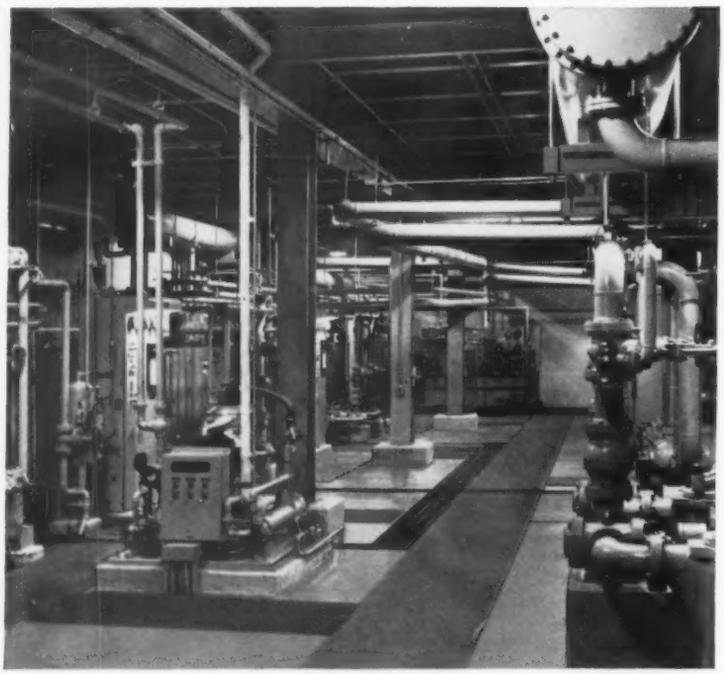
REPRESENTATIVES IN VARIOUS CITIES THROUGHOUT THE WORLD

One of the world's fastest rod mills protected by Dravo-DeLaval lubrication systems



Oil cellar at Sheffield rod mill. Designed for ease of maintenance, this installation inspires good housekeeping.

Preventive Maintenance keynoted design of the lubrication system engineered and built by Dravo for the Sheffield Division, Kansas City plant, of Armco Steel Corporation. PM is made effective, not only by automatic alarms and trouble indicators, dual reservoirs and twin filters, but also by the clean, compact layout of the oil cellar.

Five systems circulate a total of 45,200 gallons of oil at 556 gpm. There are five different viscosities and two different pressures involved. Dual reservoirs extend service life of the oil by allowing water and contaminants to settle out in the spare tank. Each of the ten tanks have automatically controlled steam heating coils, and there is a cooler for each system.

These almost maintenance-free systems were quickly and easily put in service, and required no engineering time at the site. For information on how high efficiency Dravo-DeLaval oil systems can save you time and money, write Dravo Corporation, Pittsburgh 22, Pennsylvania.

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CORPORATION

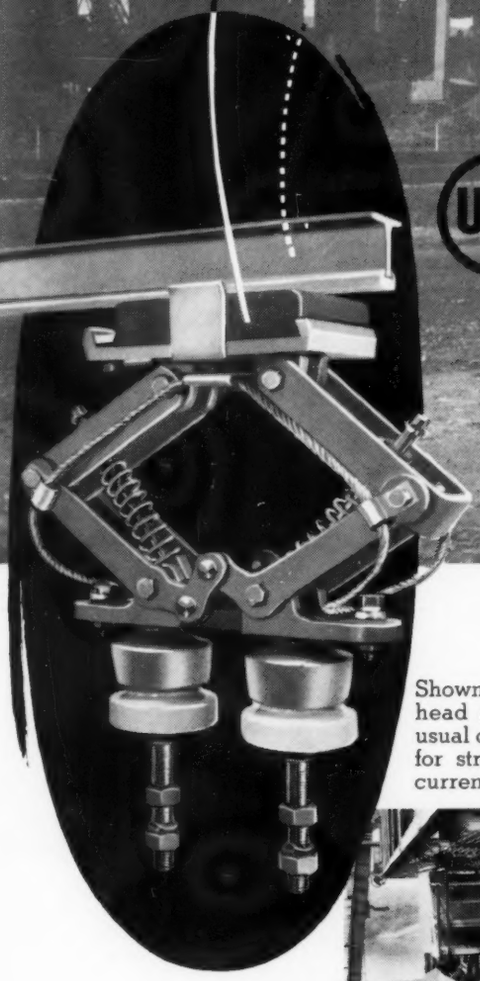
Dravo-DeLaval

OIL SYSTEMS

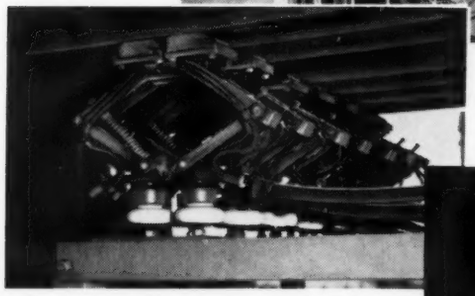
DRAVO

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

U.S. Steel's new towering 629-foot ore bridge designed and built by American Bridge for National Tube Division's Lorain, Ohio, Works.



Shown below are the copper-head steel rails. These unusual conductors feature steel for strength and copper for current capacity.



Above are the specially designed pantographs, with carbon shoes, which maintain constant contact with the copper contact surface of the conductor rails under all operating conditions.

Chosen for its low maintenance and freedom from past conductor system difficulties; this Ringsdorff Current Conductor System is now an integral part of the great ore bridge at the Lorain Works of U.S. Steel. Ringsdorff Current Conductor Systems are easily adaptable to any normal or special application in American Industry.

The Ringsdorff Current Conductor System is now being manufactured in the United States.

For specific engineering assistance, contact:

RINGSDORFF CARBON CORPORATION

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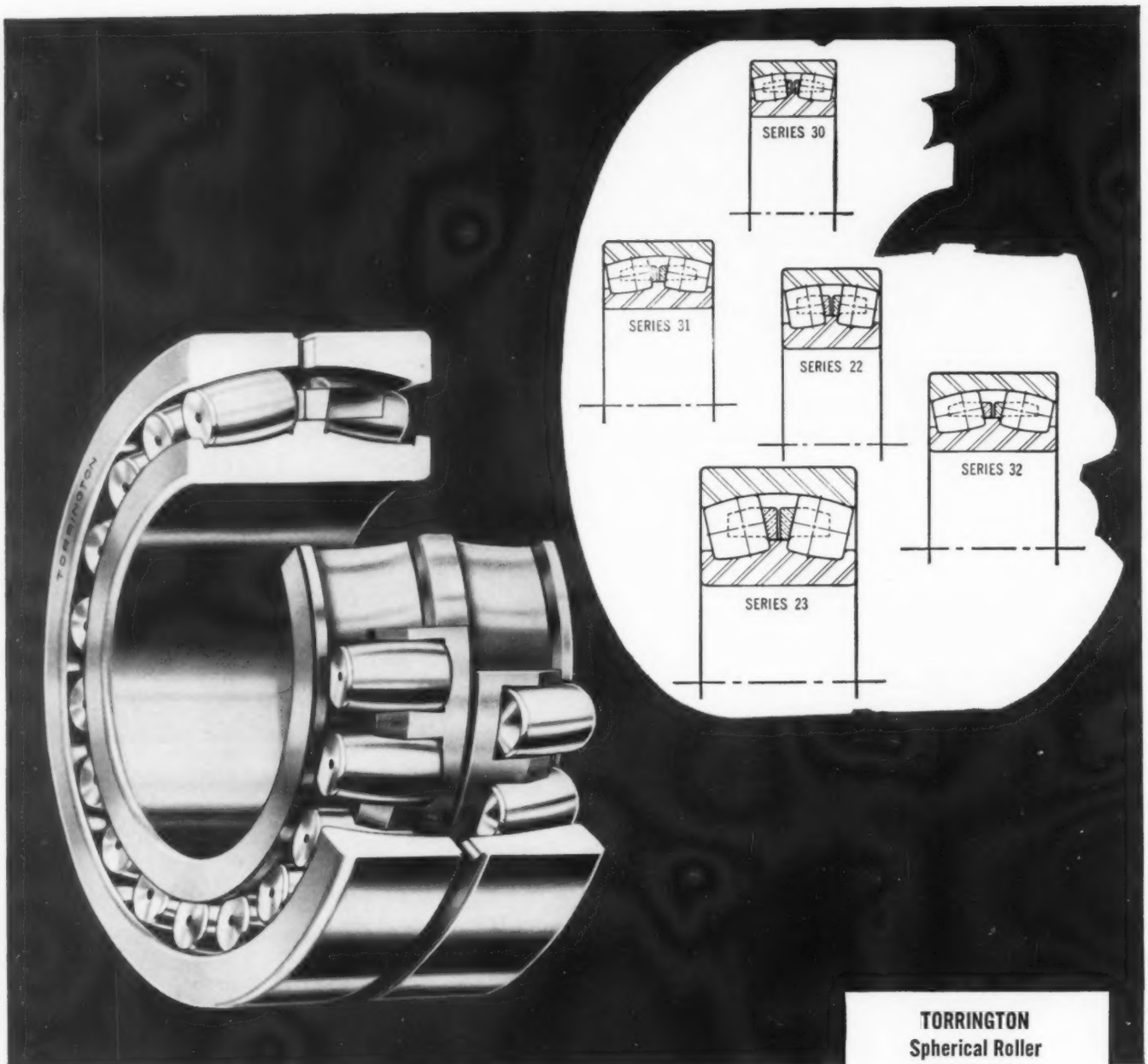

There's a Torrington Spherical Roller Bearing for your application

Bearings matched *exactly* to the job pay off in better performance, longer life, greater reliability. That's why it pays to specify carefully. And that's why it pays to choose Torrington Spherical Roller Bearings.

Whatever your space limitations or capacity requirements, the five series of Torrington Spherical Roller Bearings provide the right bearing for virtually every industrial application. You can design for straight bore or tapered bore with adapter. You can benefit from extra features such as lubrication groove and oil holes, or selected outside diameters.

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- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- inherent self-alignment
- even load distribution
- long, dependable service life

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progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

Personnel News...

George B. McMeans has been assigned to a new executive position as vice president of Kaiser Industries Corp. and of Henry J. Kaiser Co. Mr. McMeans joined Kaiser Steel Corp. in 1947 after 13 years with the John A. Roebling's Sons Co. Since 1952 he has been vice president in charge of operations for Kaiser Steel. He will continue as a vice president, but because of his new responsibilities, will no longer be in charge of operations.

Herman F. Kaiser has been appointed divisional superintendent of Republic Steel Corp's Massillon, Ohio, steel plant. In his new assignment Mr. Kaiser will oversee the operations of the company's basic steel plant in Massillon as well as the three Enduro (stainless steel) finishing plants adjacent to the steel plant. He succeeds **Joseph H. Jones,** who will continue as a consultant for the Central Alloy District. Mr. Kaiser, who has been with Republic for 32 years, has been divisional superintendent of the Canton steel plant since January, 1959. He started at the Canton plant in 1928 and served in numerous capacities in the plant's blooming mill before being named turn foreman in the mill in 1949. He was appointed assistant superintendent of the mill in 1954, and superintendent in March, 1956. **Clair W. Leasure** succeeds Mr. Kaiser as divisional superintendent of the Canton plant. A veteran of 25 years with Republic at the Canton plant, Mr. Leasure started in 1935 as a metallurgical observer in the Open Hearth Department. After carrying out similar assignments in the plant's blooming mill and bar mills, he was appointed metallurgist in the No. 1 Melt Shop in 1938. In 1942, he was named assistant superintendent of steel conditioning. **Jacob H. Judy** succeeds Mr.Leasure as chief inspector and **George M. Gotschall** succeeds Mr. Judy as assistant chief inspector at Canton. Mr. Judy started in Canton in 1923, as inspector foreman in the plant's 12-in. bar mill. He later carried out the same assignment in several other operations at the plant before being appointed assistant chief inspector in 1944. Mr. Gotschall joined Republic at the Canton plant in 1940, as a metallurgical observer. He later served as chief observer, turn metallurgist and yield engineer. He has been senior stainless steel metallurgist since 1957.

John J. Selway has been appointed general works manager of Phoenix Steel Corp.'s recently acquired plant in Claymont, Del. Mr. Selway will continue as general works manager of Phoenix's blast furnace division at Chester, Pa., a position he has held since 1955. Mr. Selway started with Weirton Steel Co. in 1929 and during the following years, was associated with U. S. Steel, Republic Steel Corp., and Wheeling Steel in various managerial capacities.

Louis F. Jagucki has been named superintendent, continuous buttweld furnaces, primary finishing and galvanizing, Benwood Works, Wheeling Steel Corp. At the same time, **Ross P. Long** was appointed superintendent of services, at Benwood Works. Mr. Jagucki has been with Wheeling Steel since 1946, all of his time with the company being at the Benwood plant. Mr. Long is a 35-year Wheeling Steel veteran, having started his career with the company as a rigger at the Martins Ferry blast furnace.

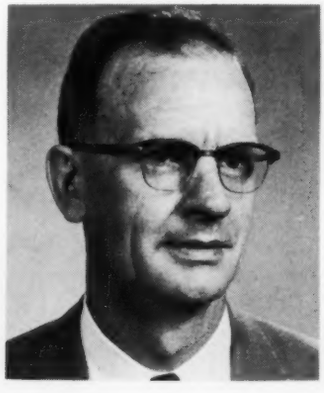
Joseph R. Zappa has been named superintendent of Republic Steel Corp.'s Union Drawn Steel Division plant in Los Angeles, Calif. He succeeds **George E. Yarnhold,** who retired August 31 after 44 years of service with Union Drawn and its predecessor company in Massillon, Ohio. At the same time, **J. Gordon Coffey** was named plant service manager at Los Angeles, and **Ralph A. Creter,** plant metallurgist and field contact metallurgist for the West Coast area.

Mr. Zappa is a veteran of 25 years with Republic and has been with Union Drawn at the Los Angeles plant since 1947. He started at Republic's South Chicago steel plant in 1935, and was named cost clerk in 1944. He was transferred to Los Angeles as assistant service chief. He has been acting assistant plant superintendent since June of this year.

Mr. Coffey has been with Union Drawn since 1933.

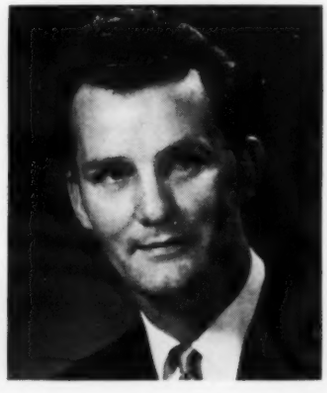
G. B. McMEANS

H. F. KAISER



C. W. LEASURE

J. J. SELWAY



E. S. HOOPES

H. R. McLAREN

R. T. SHIPLEY

H. C. JACKSON

He started at the company's Gary, Ind., plant as a production clerk and was named service chief at Gary in 1950. He was transferred to the Los Angeles plant in August of this year. Mr. Creter started at Union Drawn at its Massillon plant in 1927, as a spark tester in the metallurgical laboratory. He was appointed plant metallurgist at the company's Beaver Falls, Pa., plant in 1955.

E. S. Hoopes, formerly general superintendent of Timken Co.'s Steel & Tube Division, has been named general manager of Steel & Tube operations. **H. R. McLaren,** formerly assistant general superintendent, has been named general superintendent, Steel and Tube plants, and **R. T. Shipley,** formerly assistant superintendent of the steel plant, has been promoted to superintendent of the Canton Steel & Tube plant. Mr. Hoopes joined Timken in 1932 as a steel sales trainee and, a short time later, was transferred to the company's operating division. He was promoted to assistant general superintendent of the Steel & Tube Division in 1936 and was made general superintendent in 1943. Mr. McLaren joined Timken in 1930 as superintendent of the piercing mills. He was promoted to superintendent of the tube mills in 1937 and became assistant general superintendent of the Steel and Tube Division in 1945. Mr. Shipley joined the company in 1944 as a research assistant. He was promoted to general foreman of the melt shop in 1951 and the following year was made general foreman of the Canton steel mill. He became assistant superintendent of the steel mill in 1954.

Harry C. Jackson has been appointed assistant superintendent, Cold Strip Department, Yorkville Works of Wheeling Steel Corp. He began his Wheeling Steel career in 1950 as a practice engineer at the Benwood Works. Prior to his recent promotion, he was superintendent of maintenance at the Benwood plant.

Thomas F. Mackey has been named manager-Eastern Region, of General Electric Co.'s Industrial Sales Operation. He will be responsible for sales of electrical apparatus to industrial customers in parts of New York, New Jersey and Connecticut. Mr. Mackey joined General Electric's Engineering Test Course in Schenectady, N. Y., in 1937. Between 1939 and 1947 he held positions in the company's Industrial Control Engineering, Industrial Control Sales and Steel Mill Sales components. He was named sales manager of Iron and Steel Industries in 1947. In 1953 he was named manager of Heavy Industries Sales, and in 1955 was appointed manager of the Systems Sales Section. Since 1958, Mr. Mackey has been manager of the Industrial Commercial Section of the User Industries Sales Department.

Allan C. Nelson was named Rolling Mill Superintendent and **Arthur J. Steffes** superintendent of finishing and fabrication, Buffalo Steel Corp. Mr. Nelson previously served with U. S. Steel Corp., and in South America and Mexico in various rolling mill capacities. Mr. Steffes had been connected with Great Lakes Steel Corp., and more recently with Wickwire Spencer Steel Division of the Colorado Fuel and Iron Corp.

Leon Mollick has been appointed manager of engineering, Industrial Equipment Division, Baldwin-Lima-Hamilton Corp. He had been associated with the division as chief stress analyst for 10 years.

Anthony E. Von Alt has been named superintendent of the Blast Furnace Department at Republic Steel Corp.'s Chicago District steel plant. He succeeds **Paul D. Johnson,** who retired August 31, after 44 years with Republic. Mr. Johnson had been blast furnace superintendent at the plant since the furnace was placed in operation in 1943. At the same time, **John J. Barrett** was named to succeed Mr. Von Alt as assistant superintendent of the Blast Furnace Department. Mr. Von Alt joined Republic in 1943, as general foreman of the Blast Furnace Department at the company's Cleveland District steel plant. He was trans-

A. E. VON ALT

J. J. BARRETT

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FM Carrier Communication System

If it's necessary to whistle, shout or wave arms to communicate with crane and equipment operators in your plant, you're flirting with accidents, encouraging work lags, and inefficient operations. You can avoid them all with a system of direct, two-way voice communications.

Union Switch & Signal offers this system at a surprising low cost. The basic equipment includes transmitter-receiver units, loudspeakers, and microphones, and there is a full line of accessories to provide complete flexibility in design. Your own plant electricians can install the system—it uses existing electrical circuits. The system is easy to use—no special training needed. There's no transmission noise or outside interference—voice comes through loud and clear, and there's lots of audio power for your noisiest location.

Union Switch & Signal Carrier Type communication systems are used extensively in steel, railroad, and mining operations. The equipment is rugged and dependable, and uses the very latest and best developments in electronic circuitry. Don't miss this chance to improve your operation. Check the coupon.

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MEMO

TO— OXYGEN STEEL OPERATORS!

"virtually no maintenance since start-up on

CHEMICO VENTURI WASHERS"

Where major investments are concerned, performance is vital. At the Algoma Steel Company's new Sault Ste. Marie Basic Oxygen Steel plant, Chemico Venturi washers are exceeding all original performance specifications. Case in point: since start-up in November, 1958, there has been virtually no maintenance on the Chemico washers. This is a normal record for Chemico washers. They are designed to eliminate shut downs for maintenance on gas washing systems, thus making it unnecessary to invest in spare equipment.

Chemico Venturis are paying Algoma other dividends, too, for these washers are operating at better than 98% efficiency. During test periods when operating at 50% over design capacity, the flexibility of the Chemico washers permitted the extra load to be handled without increased washing facilities.

If steel is your business and air pollution your problem, it pays to consider Chemico Venturi washers. You can obtain full information, a copy of a detailed technical brochure, and technical assistance concerning your problem by writing Chemico today.

CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
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R. A. WARFIELD, JR.

J. A. BRAY

C. W. SISCO

R. I. BROWNING

ferred to the Chicago plant's Blast Furnace Department as general foreman in 1946, and became assistant superintendent of the department in 1959. Mr. Barrett also joined Republic in 1943. He started as blower foreman at the Chicago plant after three years at Interlake Iron in Chicago.

Ray. A. Warfield, Jr., has been appointed senior product supervisor of the Quality Control Department of The Colorado Fuel and Iron Corp.'s Pueblo, Colo., plant. Mr. Warfield had been serving as quality control product supervisor at Pueblo since 1952. He joined CF&I in 1950 as a junior metallurgist in the Quality Control Department. At the same time, **Andrew Lamberson** was appointed product supervisor, Eastern Zone, of the Quality Control Department, and **Harold Newton** was appointed product supervisor, Colorado Zone.

James A. Bray has been appointed to the new position of manager of trade relations of the E. W. Bliss Co. Mr. Bray had been associated with the Mackintosh-Hemphill Division of the company, most recently as assistant general sales manager.

Carl W. Sisco has been appointed sales manager of steel mill equipment by Surface Combustion Division of Midland-Ross Corp. Mr. Sisco has been with Surface Combustion for 24 years. In 1953 he was transferred to the Pittsburgh office and appointed district sales manager. **Ray E. Kranz** has been appointed Pittsburgh district sales manager of steel mill equipment. Mr. Kranz has been with Surface Combustion for 12 years. He served in the Equipment Erection Department and steel mill sales office in Toledo, until he was transferred to Pittsburgh in 1956. **Robert E. Strutner** has been transferred from the Toledo sales office to the Pittsburgh steel mill equipment sales staff. Also, **Richard J. Light,** metallurgical engineer and supervisor of the metallurgical laboratory in Toledo has been appointed to the steel mill sales staff in Toledo.

Robert I. Browning has been appointed manager of the newly-created Pittsburgh region of Crouse-Hinds Co. He joined the organization in 1936, working in the home office in Syracuse, N. Y., before his transfer as a product engineer to the San Francisco, Calif., office in 1949. At the same time, **James E. Blake** was appointed regional manager of the company's New York region. Mr. Blake was formerly a product engineer in Newark. He began his career with the company in 1949, working in various departments in the Syracuse plant before his transfer to the field.

Frank J. Nunlist has been appointed to the new position of vice president—operations of Worthington Corp. In his new position Mr. Nunlist, formerly a group vice president, will be responsible for the activities of all the company's sixteen domestic operating divisions and regional engineering and service activities.

Charles W. Bowden, Jr., was promoted to industrial sales manager of Minneapolis-Honeywell Regulator Co.'s International Division, and **Arthur O. Dietrich,** succeeds him as advertising and sales promotion manager of Philadelphia-based divisions. Mr. Bowden fills a new post, created to facilitate expansion of overseas markets for industrial process instruments.

Polish metallurgical samples easier, better, more uniformly with . . .

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LAPPING-POLISHING MACHINES

—whether it's one or a number of specimens to be polished, SYNTRON Vibratory Lapping-Polishing Machines will produce a metallographic finish for an electron microscope or brush analyzer examination.

Gentle, electromagnetic vibration moves the specimens smoothly around the pan, over abrasive cloth or felt polishing cloth. Both abrasive and felt cloths are removable.

SYNTRON Lapping-Polishing Machines are easy to install, easy to operate, easy to maintain.

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Quality Equipment Since 1921

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G. H. BAILEY W. M. ADLER

George H. Bailey has been appointed Western sales manager for National Bearing Division, American Brake Shoe Co. He will have headquarters in Oakland, Calif. Mr. Bailey was formerly regional sales manager for the division, located in Cleveland, Ohio.

William M. Adler has been named manager of sales for the National Alloy Division, Blaw-Knox Co. He had been eastern region district manager for the National Alloy Division. He also represented the Power Piping Division in the Philadelphia area.

Alfred S. Harries has been appointed refractories sales representative for the Pittsburgh district sales office of The Babcock & Wilcox Co. He has been associated with B&W since 1933 when he joined the company's Augusta, Ga., refractories plant as an apprentice brickmason. Prior to his new appointment he served as refractories sales representative in the company's New York sales office for six years.

Herbert L. Tygesson has been appointed general sales manager of the Automatic Transportation Co. He succeeds **R. D. "Bill" Jones,** who resigned to go into business for himself.

J. James Offutt was named vice president and general manager of A. P. Green Fire Brick Co. In his new capacity, Mr. Offutt will be responsible for the direction of all manufacturing, sales, research and engineering of the company. Also announced were the appointment of **Jack W. Swatek** as director of sales, and **H. L. (Butch) Beynon** as general sales manager.

T. J. Pohl was named sales manager for the Insulation Division of M. H. Detrick Co. He joined the Detrick organization in September, 1959.

Obituary

Dr. George Sachs, associate director, Metallurgical Research Laboratory, Syracuse University Research Institute, and supervisor of the Joint RMI and AISE Roll Breakage Research Program, died suddenly on October 29. Dr. Sachs was an internationally known author, teacher and consultant in the metallurgical and rolling fields, originally coming from Germany where he was educated.

Donald K. Martin, sales manager of steel mill equipment, Surface Combustion Division of Midland-Ross Corp., died September 15. He was 55.

EXECUTIVE REPORT #11

HERE CARBON STEEL SHEDS ITS SCALE

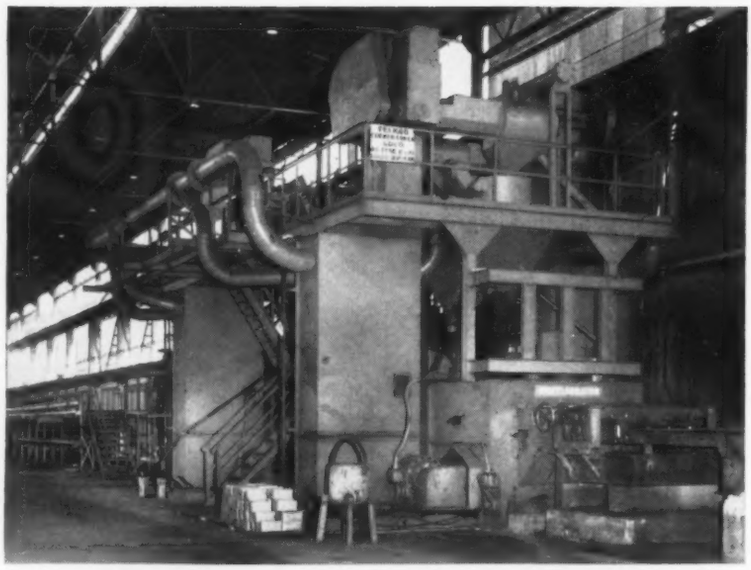
Wheelabrator® Descaling Enables 100% Increase in Production

Every ton of steel produced in the modern mill of Altos-Hornos De Mexico, S.A., at Monclova, Coahila, is run through a Wheelabrator airless blast descaling cabinet. In a typical month, over 15,500 tons of carbon steel from a hot Steckle reversing type mill was Wheelabrator descaled followed by a light pickle rinse. The end product is reduced on reversing cold mills for sale as cold rolled steel, tin plate, and galvanized stock.

Steel is descaled in this new line at a rate of up to 200 f.p.m. contrasted to a speed of only 100 f.p.m. when acid pickling was used exclusively for descaling. Even with this increase in production, acid consumption has been cut in half and overall descaling costs materially reduced.

Wheelabrator Engineering Experience At Your Service

Write today for information on how Wheelabrator descaling can cut your costs and speed production. Wheelabrator Corporation, 396 S. Byrkit St., Mishawaka, Indiana. In Canada, P.O. Box 490, Scarborough, Ontario.



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AIRLESS BLAST EQUIPMENT

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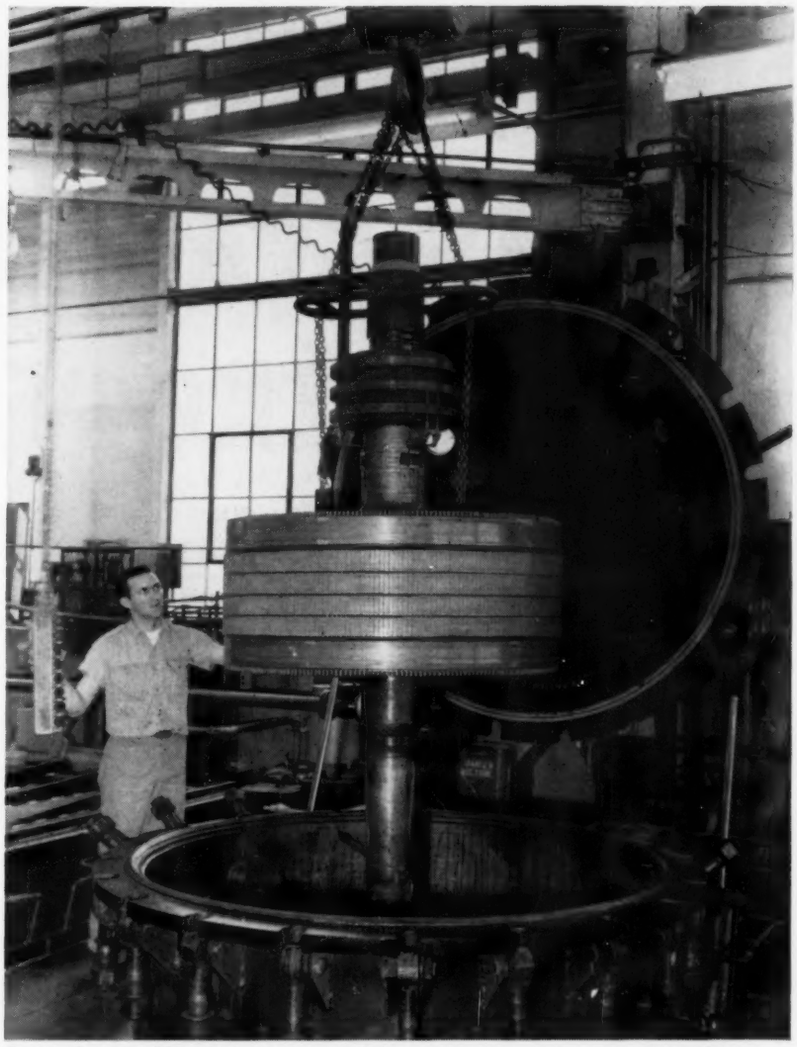
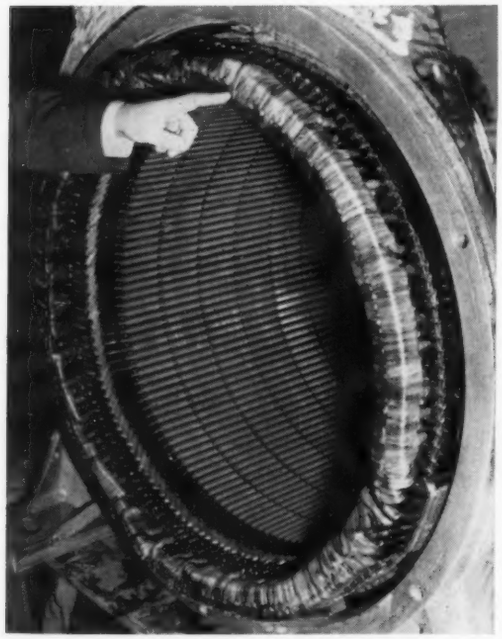
NATIONAL VACUUM-IMPREGNATES THE COMPLETE MOTOR WITH EPOXY

National offers superb facilities for rewinding and rebuilding rotating electrical machines...such as this large vacuum tank used in impregnating insulations with super-strong Epoxy resins. Not only single coils, but complete rotor and stator assemblies for large motors are regularly handled in this equipment.



Rotor for 750-HP Motor is lowered into huge vacuum-pressure tank.



Complete stator assembly with NECCOBOND insulation system, after vacuum impregnation with Epoxy resins.

This process, used with the NECCOBOND insulation system provides these assurances of maximum service life:

- the insulation wall is completely void-free, with all interstices filled with resin to provide maximum heat conductivity.
- the exceptional mechanical strength and adhesion of Epoxy resin bonds the entire winding and core into a solid mass.
- uniform encapsulation provided by National's method of baking, insures high degree of protection against moisture.

Whether your electric coil and rebuilding needs are standard or special, you'll be sure of performance when you call in National Electric Coil. We tailor-make the coils to fit your needs, offer all types of insulation. For information call National's Columbus plant ...HUdson 8-1151...or check the nearest National field engineer.

NATIONAL COILS

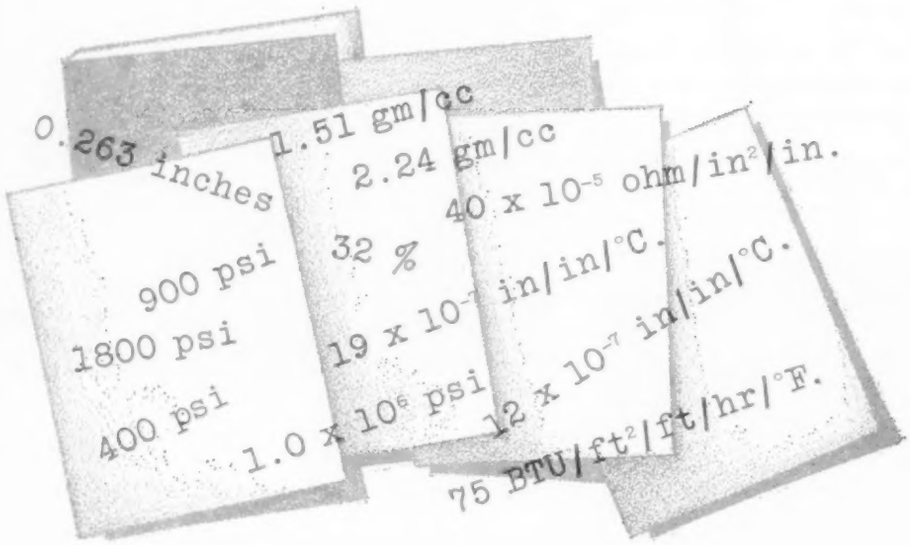
National Electric Coil

COLUMBUS 16, OHIO • IN CANADA: ST. JOHNS, QUEBEC

DIVISION OF McGRAW EDISON

NEW TECHNICAL DATA SHEETS AVAILABLE TO GLC ELECTRODE USERS

Recently issued data sheets prepared by our Technical Department contain important information about graphite electrode properties.



Among the typical physical properties detailed for electrodes in various grades and sizes are maximum particle size... apparent and real density... porosity... resistivity... rupture... compressive and tensile strength... elasticity... thermal expansion and conductivity.

Typical chemical properties of the electrode grades show percentages of ash, sulfur, silicon, iron, calcium, aluminum, vanadium and other impurities.

We shall be happy to furnish a set of these electrode technical data sheets, with our compliments, to electric steel furnace operators everywhere. Your request will be most welcome.

PRODUCTS ELECTRODE GLC DIVISION YOU CAN TRUST ©

GREAT LAKES CARBON CORPORATION

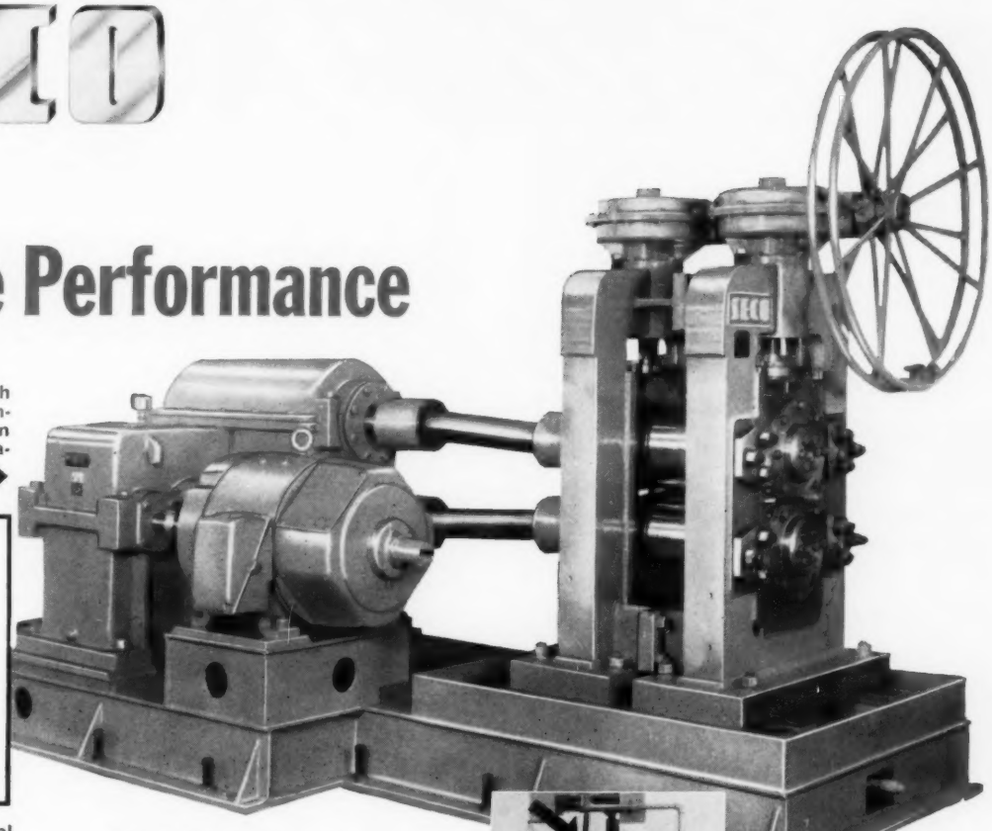
18 EAST 48TH STREET, NEW YORK 17, N. Y.

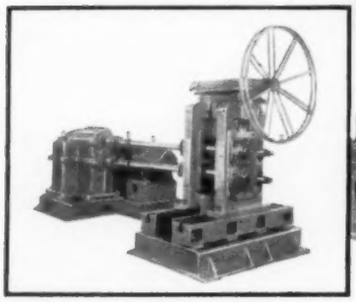
Whatever your requirements . . . SECO's staff of trained engineers can help you solve any special Mill problem you may have . . . from creative designing through installation (including *all* required auxiliary equipment).

Should your problem involve a special Cluster Mill (to accommodate either ferrous or non-ferrous metals), or a Hot Rolling Mill that bonds non-ferrous metal to a steel base . . . SECO can supply.

Custom Built HOT ROLLING MILLS *by* SECO *assures* Predictable Performance

A special, custom-built 2-high Hot Roll Flattening Mill for non-ferrous metals. (Can be built in 2 or 4-high types or a combination of both.) ▶

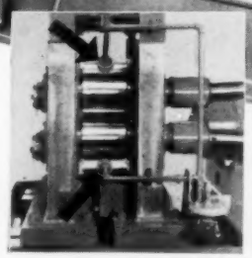




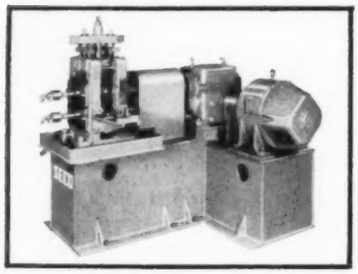
▲ A SECO designed and built Bi-Metal Bonding Mill on movable mountings.

Special Features: ▲

- Water-cooled chocks for lubrication
- 900° F. rolling temperature
- Hand wheel screw-down (adaptable for power)
- Special alloy steel rolls
- Timken Tapered Roller Bearings
- Can be built for 8, 10, 12 or 16-inch widths.



◀ Mill is equipped with two gas jets as a means for pre-heating rolls (see arrows).



▲ A 6-inch, 2-high Wire Flattening Mill for single or tandem use.

SECO

STEEL EQUIPMENT COMPANY

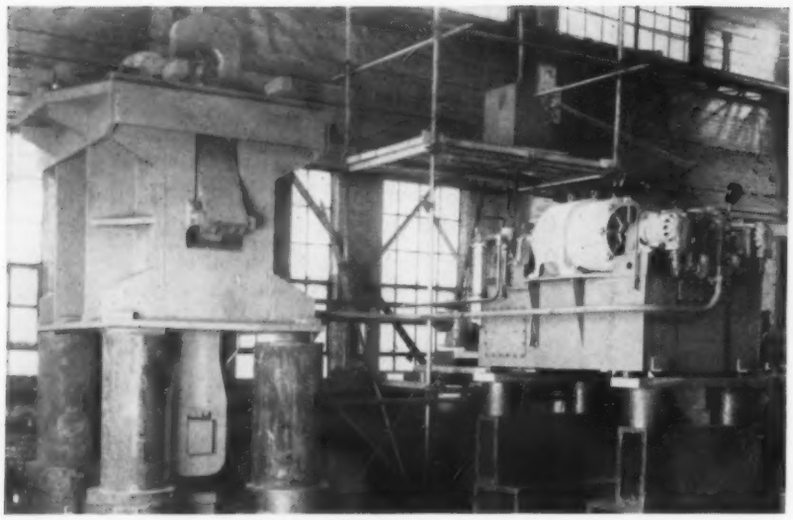
P. O. BOX 737, WARRENSVILLE STATION

CLEVELAND 22, OHIO

SECO STEEL MILL EQUIPMENT

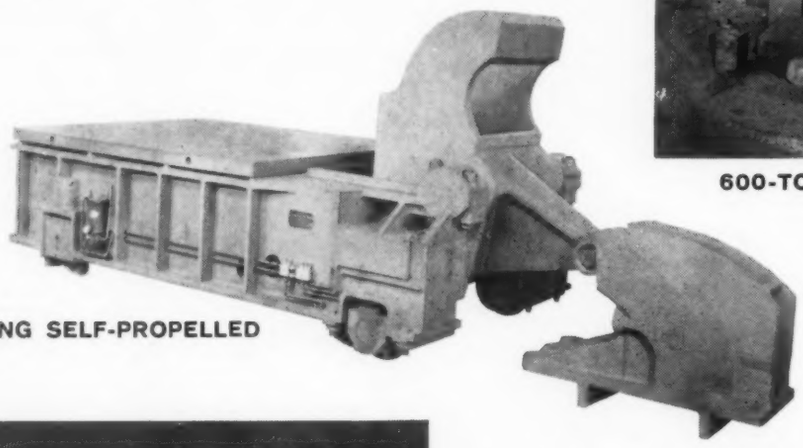
- Leveling and Shearing Lines
- Combination Edging and Flattening Lines
- Tension Reels for Strip Polishers
- Narrow Strip Grinding Machines
- Slitting Lines
- Multiple Strand Pull-out Rolls and Take-up Frames
- Strip Coilers (Up and Down Type)
- Traverse Reels for Narrow Strip
- Steel Coil Up-enders
- Scrap Ballers

Affiliated with Lee Wilson Engineering Co., Inc.



800-TON INGOT STRIPPER

600-TON INGOT STRIPPER



FORWARD-TILTING SELF-PROPELLED INGOT BUGGY

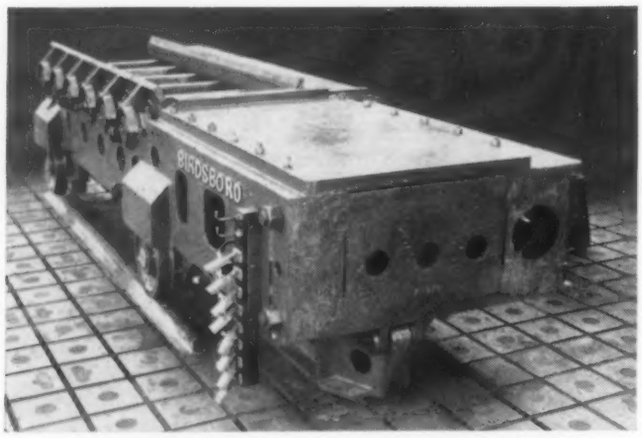
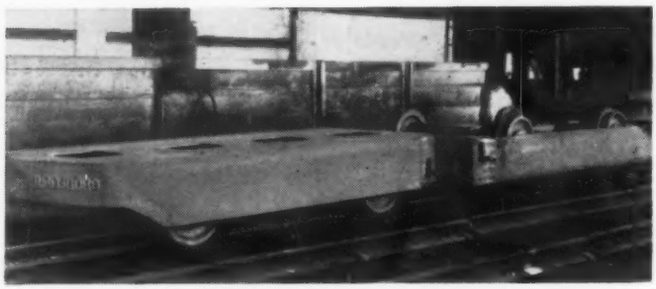
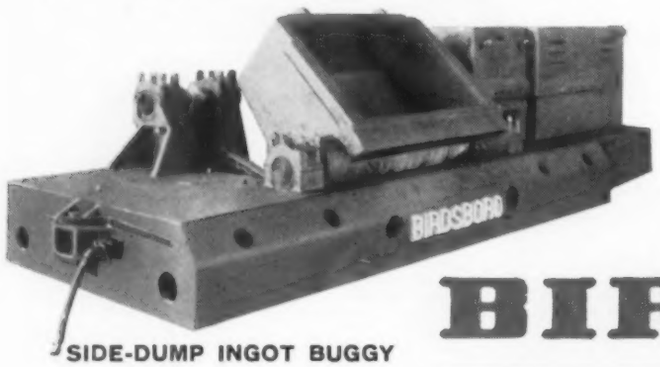


TABLE-TYPE SELF-PROPELLED INGOT BUGGY



INGOT TRANSFER CARS



SIDE-DUMP INGOT BUGGY

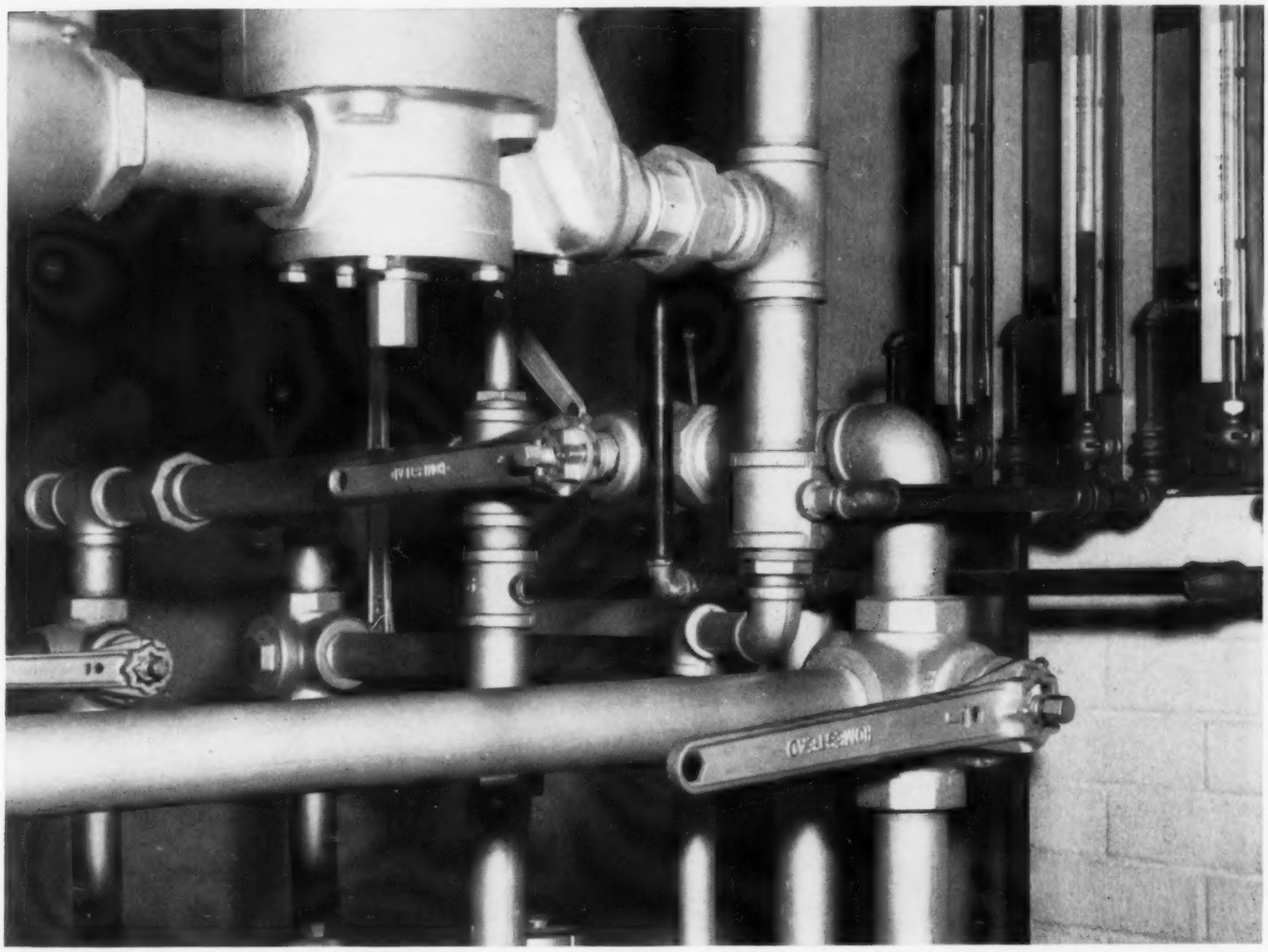
Ingot Handling Equipment *designed and built by*

MM89-60

BIRDSBORO
CORPORATION

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • ROLLS
ELECTRIC STEEL CASTINGS: Carbon, Low Alloy and STAINLESS STEEL • **BIRDSBORO, PENNSYLVANIA**

CLOSE TOLERANCE—KEYNOTE TO LOW-COST MAINTENANCE—is yours with Homestead® Lubricated Plug Valves. Vital to efficient fluid control, this close tolerance between sealing surfaces



(.002″ maximum clearance on sizes up to 2″, .003″ to .005″ maximum on larger sizes) plus Homestead's high-pressure lubricant system guarantee complete coverage of sealing surfaces. You are assured protection against corrosive, abrasive or erosive line fluids as well as a longer-lasting seal against leakage. Sticking is eliminated, too, by downward movement of plug during each lubrication. The net result for you is positive fluid control at very low cost per year.

hv

HOMESTEAD VALVE MANUFACTURING COMPANY
"Serving since 1892"
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160

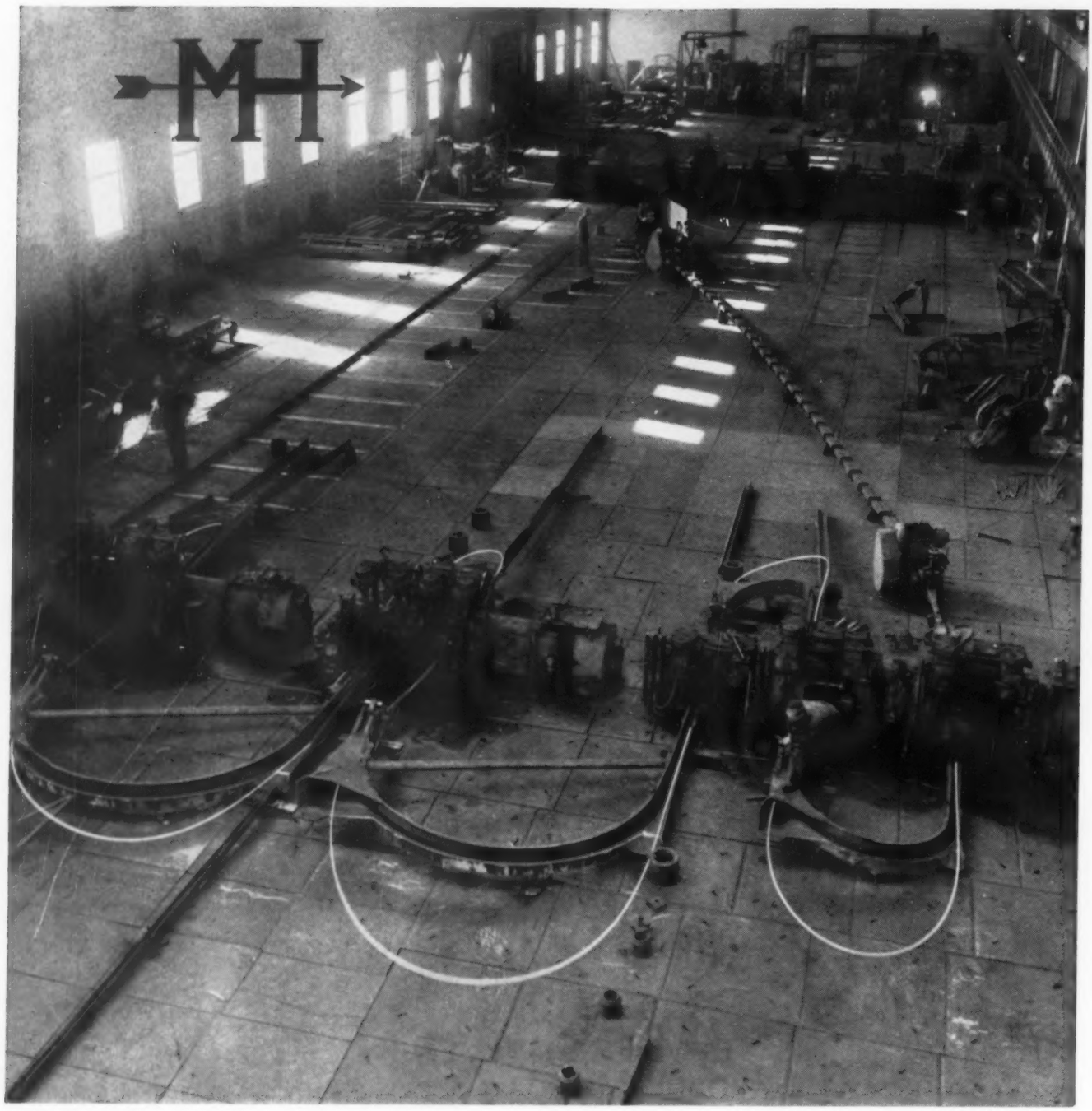
Please send Reference Book 39-1 and prices on Homestead Lubricated Plug Valves:

Name ..... Title .....

Company .....

Address .....

City ..... Zone ..... State .....



Combined Rolling Mill for medium and small sections and wire rod

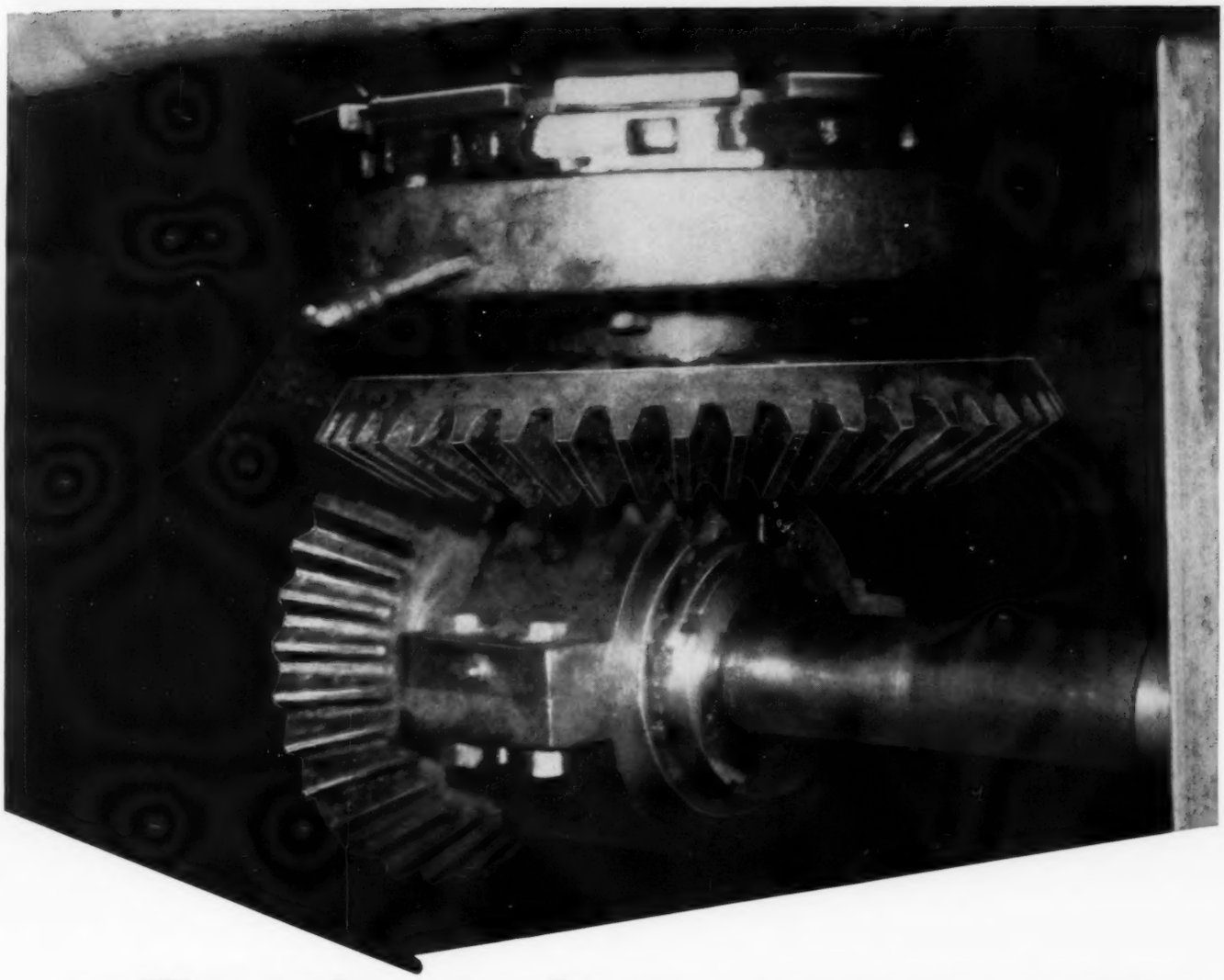
Morgårdshammar Combined Rolling Mills for high grade steels are designed to give closest possible tolerances and to allow the rolling of a large assortment of dimensions and sections, from 5 in. down to about 5/16 in. round.

For further information, please apply to us for reprints from the Journal of the Iron and Steel Institute.

Swedish Quality

MORGÅRDSHAMMAR

MORGÅRDSHAMMARS MEK. VERKSTADS AB • MORGÅRDSHAMMAR



a Bearings, Inc. conversion with a 2 year record of no lost production, reduced maintenance . . . and a 30% Power Savings!

Over two years ago our engineers converted this main drive gear from a babbitt bearing to a ball bearing unit on a machine in a customer's plant. Performance of this conversion, according to company engineers, has been outstanding! The housing for the bearings as well as the gear hub was produced by the customer in their own machine shop.

Prior to conversion, machine downtime was excessive because the babbitt had to be repoured every three or four months. A plus saving was in the reduction of power required to operate the machine. The customer now finds power consumption is 30% less!

If your older equipment can be modernized with anti-friction bearings — our engineers can show you how. If you need bearings for any purpose, our stock carrying branches can supply you. We are authorized distributors of most nationally known makes of bearings. We and the makers guarantee every bearing we supply.

Call the branch nearest you now!

Providing bearing service in the North → **BEARINGS, INC.**

DELAWARE: Wilmington • **ILLINOIS:** Neiman Bearings Co., E. St. Louis • **INDIANA:** Ft. Wayne • Indianapolis • Muncie Terre Haute • **MARYLAND:** Baltimore • **MISSOURI:** Neiman Bearings Co., St. Louis • **NEW JERSEY:** Camden • Newark **NEW YORK:** Balanrol Corp., Buffalo • Niagara Falls • **OHIO:** Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton Lima • Lockland • Mansfield • Painesville • Toledo • Youngstown • Zanesville • **PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • York **WEST VIRGINIA:** Charleston • Huntington • Parkersburg • Wheeling

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ARKANSAS: Little Rock • **FLORIDA:** Jacksonville • **GEORGIA:** Atlanta • **KENTUCKY:** Louisville • **LOUISIANA:** Baton Rouge New Orleans • **N. CAROLINA:** Charlotte • Greensboro • **S. CAROLINA:** Greenville • **TENNESSEE:** Chattanooga • Kingsport • Knoxville Memphis • Nashville • **VIRGINIA:** Norfolk • Richmond • Roanoke

New!

Now Bethlehem forges every hardened steel roll from vacuum-degassed steel!

Bethlehem vacuum-degassed steel minimizes the hazard of roll breakage.

Pint size, king size, every in-between size. Now Bethlehem forges *every* hardened steel roll from vacuum-degassed steel.

PIONEER IN "VACUUM CASTING"

Bethlehem pioneered the development and use of vacuum-degassed ingots for highly stressed applications in the electric power, atomic energy, and other industries.

With our advanced steel-pouring techniques, we can pour molten steel from a furnace ladle to a secondary ladle within a vacuum chamber, and thereby remove harmful gases (we can also pour directly into a mold in the vacuum chamber). The secondary ladle is then taken out of the chamber and ingots of suitable size for hardened steel rolls can be cast under a blanket of inert gas.

LESS GAS MEANS SOUNDER STEEL

Because the vacuum-casting method reduces the volume of hydrogen and other gases, the steel is sounder, tougher, and cleaner than air-cast steel. It is this greater internal soundness which reduces the hazard of roll breakage.

OVER 350 ROLLS NOW IN SERVICE

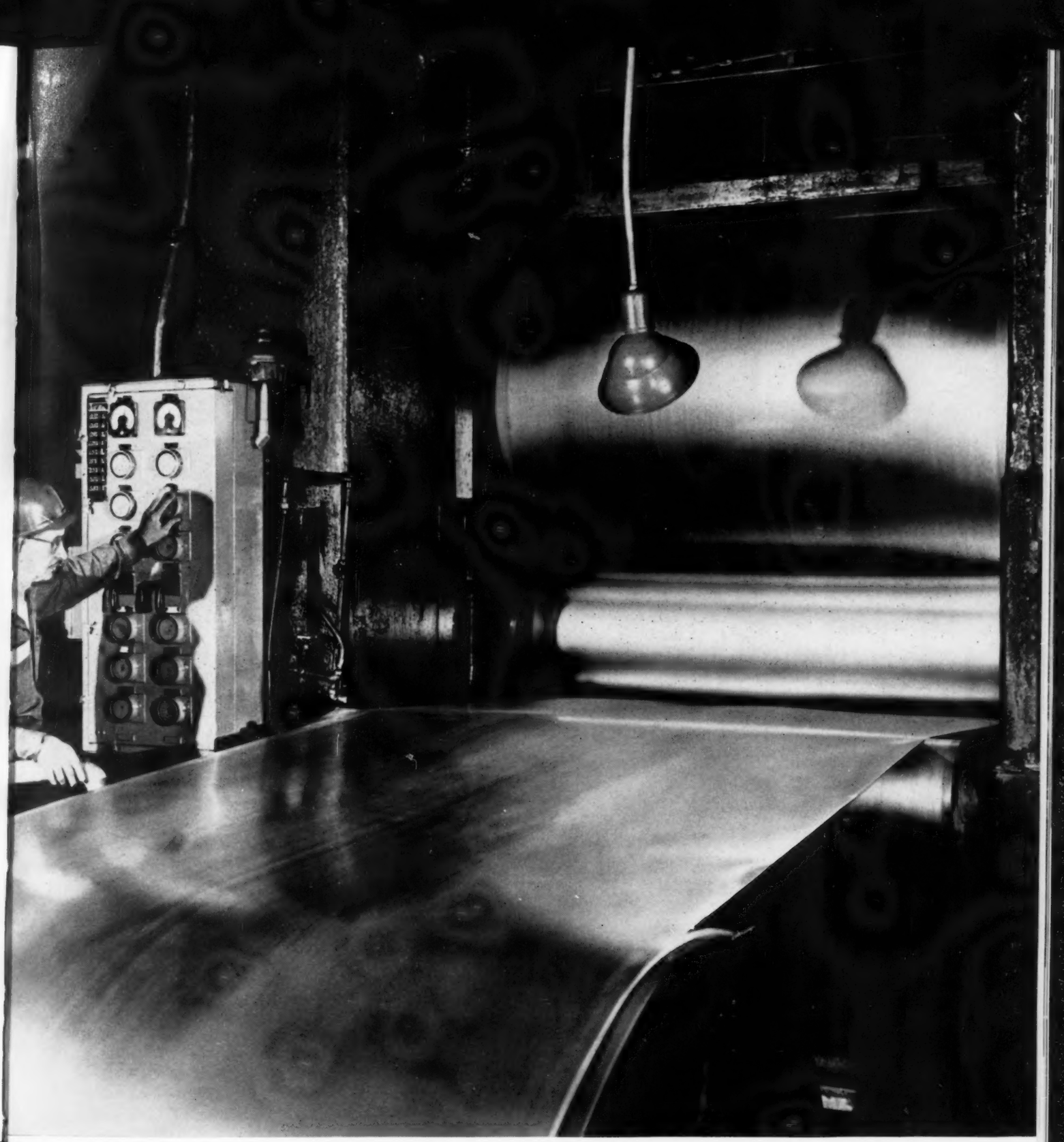
In the past several years, we've produced and shipped more than 350 large, vacuum-degassed hardened steel rolls. The outstanding performance of these rolls in our own mills confirms the superior soundness of vacuum-cast rolls as compared to air-cast rolls.

FAST DELIVERY . . . NO EXTRA COST

You have everything to gain (less roll breakage), nothing to lose (no price extra) by making your next purchase of hardened steel rolls Bethlehem vacuum-degassed rolls. Deliveries are excellent. Our sales offices are ready to give you the *whole* interesting story of this new Bethlehem development. Call or write the office nearest you today. Or write to us at Bethlehem, Pa.

LOOK FOR THIS LABEL on the packing of the hardened steel rolls you buy. It's your guarantee that your rolls are forged from Bethlehem vacuum-degassed steel . . . steel that minimizes the hazard of roll breakage in your plant.

LOOK FOR THIS "V" STAMP on the ends of the rolls you buy . . . "V" is for vacuum. You'll find this permanent identification on every Bethlehem roll from now on . . . because from now on Bethlehem will forge *only* from vacuum-degassed steel.



BETHLEHEM VACUUM-DEGASSED ROLLS are made for every application—cold-rolling steel sheet, strip, tinplate, and non-ferrous metals. Every roll meets your specifications exactly on size, shape, hardness, and finish.

Steel

For strength
. . . economy
. . . versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

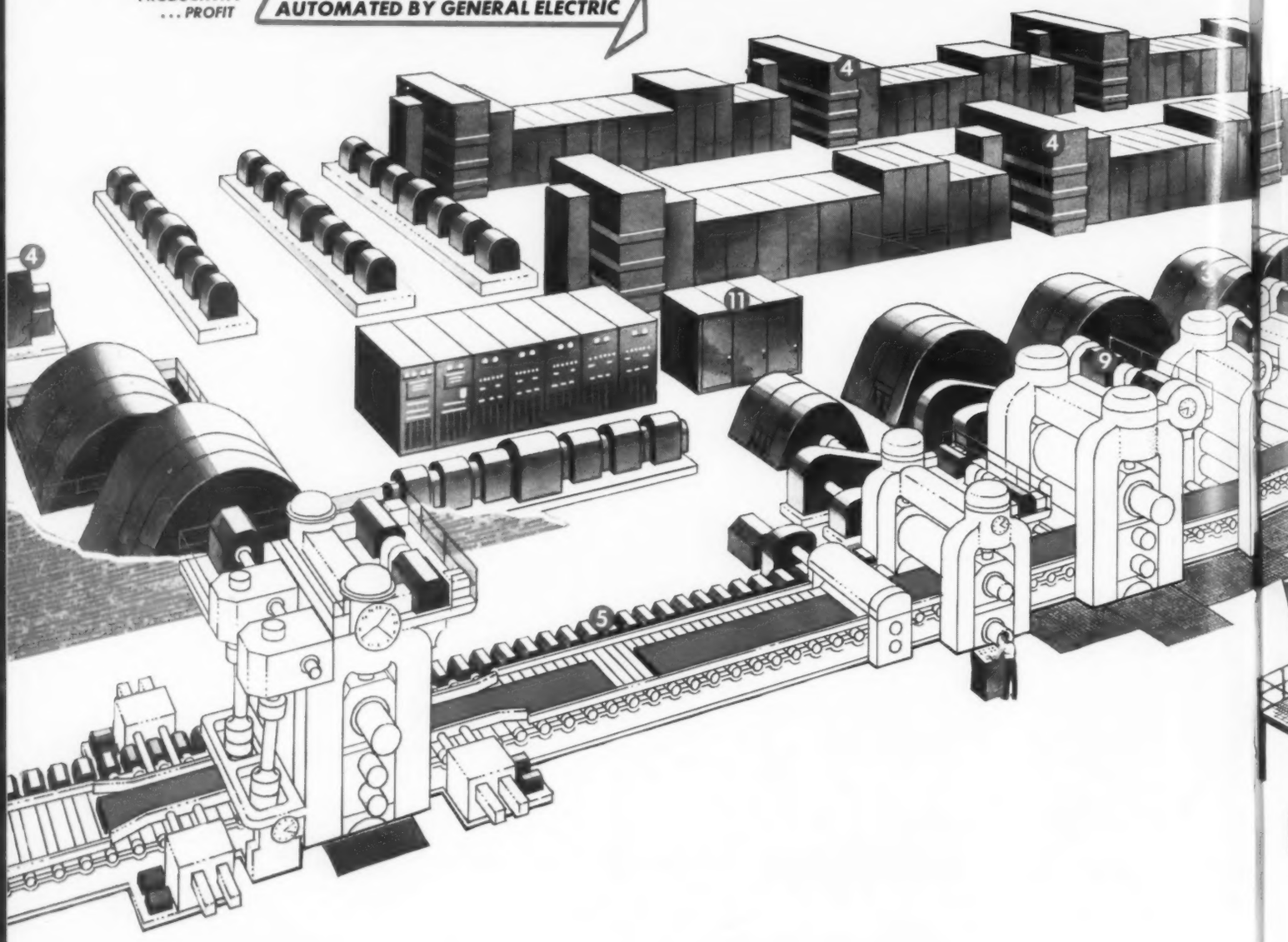
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

FOR QUALITY... PRODUCTIVITY ... PROFIT

HOT STRIP MILLS AUTOMATED BY GENERAL ELECTRIC



GENERAL ELECTRIC'S STEP-BY-STEP APPROACH TO AUTOMATION IS . . .

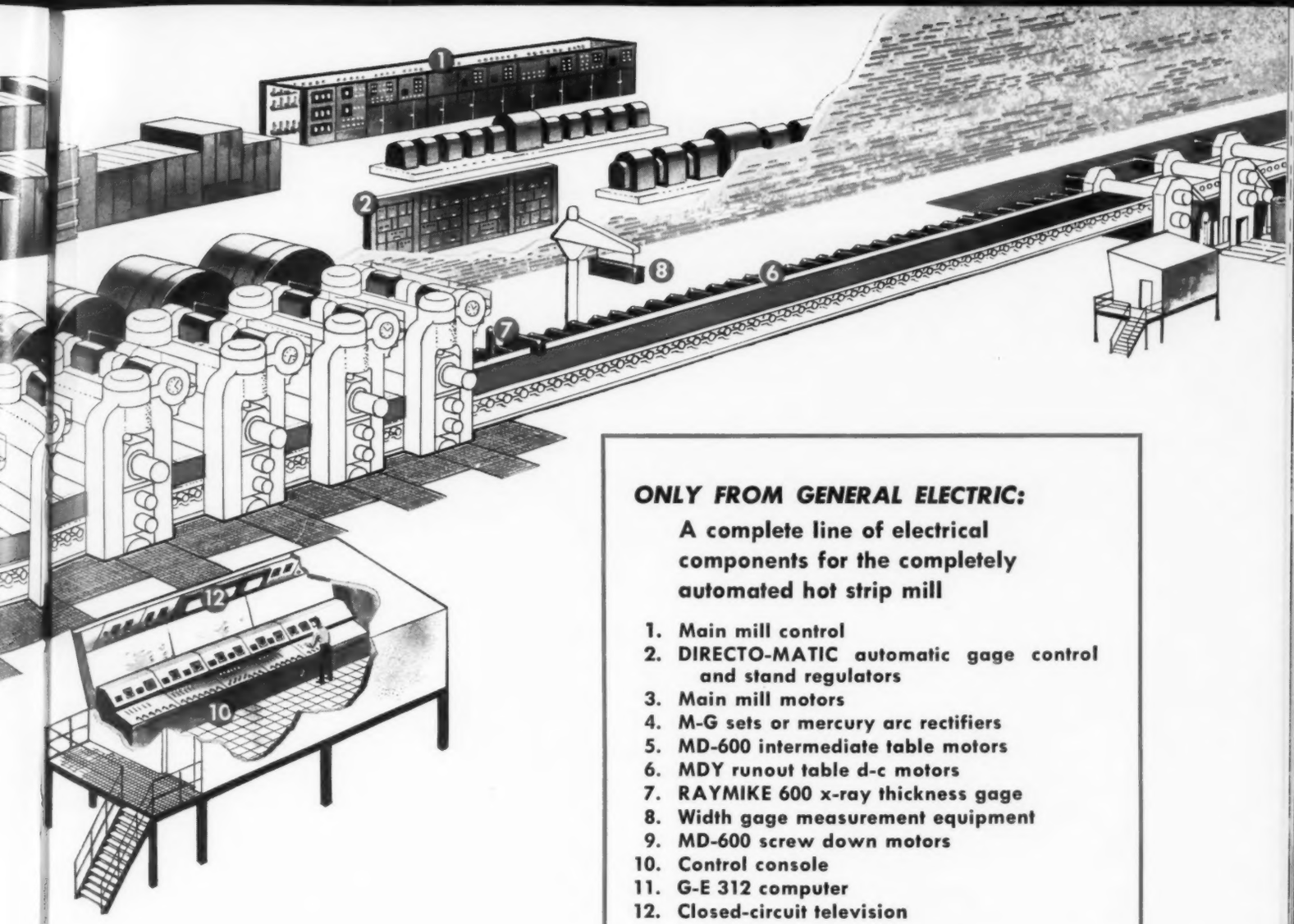
Your key to more efficient control,

EFFICIENT CONTROL and more effective utilization of production systems to meet fluctuating market trends, represents one answer to the low profit problem of undercapacity production for many primary metal producers. As a result, management has become increasingly cognizant of the benefits offered through automation of presently utilized production facilities. Meeting the demands of this trend is General Electric's planned approach to automation which combines economic soundness with predictable benefits.

WITH GENERAL ELECTRIC'S PROGRAM, critical facilities are modernized first. Then, as economic conditions warrant, a complete production area or your entire plant can be automated. Thus, by employing General Electric's logical implementation plan, greater profits are realized due to more efficient utilization of mill facilities, even though production curves decline as a result of changing market conditions.

TYPICAL BENEFITS derived from General Electric's step-by-step approach are inherent in the automation of a hot strip mill:

- **Reduction of scrap losses.** Installation of automatic gage control equipment can reduce strip cobbles as much as 27 percent, lost rolling time as much as 35 percent. Prescribed gage tolerances are met through the entire production run . . . means greater useful surface area per ton of strip produced.
- **Increased mill utilization.** Programming of each stand assures optimum performance and compatibility with adjacent operations. Operating delays and man-hours are reduced . . . mills become more efficient and greater production economies are realized.
- **Reduction in coil diversions.** More exact, continuous automatic control yields desired coils in accordance with customers' orders due to precise rolling capabilities of automated equipment. Since facilities produce only what is required, mills operating under capacity increase production efficiency.
- **Mechanical maintenance savings.** Automation reduces costly down-time and possible equipment replacement due to mechanical breakdowns and damages traceable to equipment abuse.



ONLY FROM GENERAL ELECTRIC:

A complete line of electrical components for the completely automated hot strip mill

1. **Main mill control**
2. **DIRECTO-MATIC automatic gage control and stand regulators**
3. **Main mill motors**
4. **M-G sets or mercury arc rectifiers**
5. **MD-600 intermediate table motors**
6. **MDY runout table d-c motors**
7. **RAYMIKE 600 x-ray thickness gage**
8. **Width gage measurement equipment**
9. **MD-600 screw down motors**
10. **Control console**
11. **G-E 312 computer**
12. **Closed-circuit television**

effective production and greater profit

- **Improved raw material for cold mill operation.** Coils of uniform thickness minimize weld cobbles in cold mill operation, improve quality of the strip produced.
- **Increased management control.** Systems automation provides management with efficient control of manufacturing and scheduling operations. Status reports on various mill operations are readily available for effective and timely business decisions by management. Customers are assured of accurate scheduling of orders. Automated facilities permit early detection of order problems and prevent production delays which could seriously affect customers maintaining minimum inventories.

Automation of hot strip mill facilities represents but one example of what General Electric's plan can do to increase production efficiency, reduce operating costs, minimize maintenance expenditures, improve production quality and provide more effective management control—all for greater profit.

Today General Electric is ready to meet your challenging requirements for automation. Only at General Electric will you find the technology, and advanced electrical equipment capable of providing *any degree* of automation. For your key to more efficient production and greater profit through automation, contact your nearest General Electric Sales Engineer, or write, General Electric Company, Section 659-04, Schenectady 5, New York.

AUTOMATION THROUGH MODERNIZATION

GENERAL ELECTRIC

At Kennecott's new refinery... Twin Heroult Electric Furnaces designed

Copper cathodes are charged into the 13,500 KVA Heroult 90-ton electric arc furnace, one of two at Kennecott Refining's new plant south of Baltimore. American Bridge also fabricated and erected the plant's structural framework.

to keep 16,500-ton per month copper melt on schedule

Kennecott Refining Corporation's electrolytic copper refinery near Baltimore is the country's newest—a showplace of efficiency. One reason: a pair of 90-ton Heroult electric arc furnaces, each rated at 40 tons per hour.

Of nose-tilt design to facilitate launder pouring, they discharge a steady stream of molten copper (2150°) which is used in the horizontal casting of wire bars and the continuous casting of billets. One Heroult is on normal capacity operation while the other is a spare for use during relining, when the pre-heat furnace is down, or when additional production is required.

Copper cathodes are preheated to about 1400°F and door charged into the Heroult arc furnace on a peel arm crane. The three-phase power input utilizing ultra-high speed mechanical positioning for three 20″ electrodes with high-speed sensitive regulators maintains a constant arc above the copper bath for uniform temperature casting.

The two 90-ton Heroult arc furnaces can be tilted 40° forward and 15° backward. They feature mechanically positioned masts and special water-cooled skew-back roof rings that introduce water flow at the critical roof juncture to prevent warpage and burn out.

Whatever your arc-melt problem there is a Heroult electric arc furnace design for you. We've made them from 3 tons to over 200 tons capacity, for both swing roof top charge or door charge operation. They can accommodate induction stirring equipment, and can be designed for duplexing arrangements. And every Heroult is designed for maintenance by your own crew.

American Bridge has a complete electric furnace service that includes new installation, furnace modernization and part replacement. We'll be happy to quote on your building needs, too. Call our nearest office.

USS and Heroult are registered trademarks

American Bridge Division of United States Steel

USS

General Offices: 525 William Penn Place, Pittsburgh, Pa. Contracting Offices in New York, Philadelphia, Chicago, San Francisco, and other principal cities.
United States Steel Export Company, New York

This mark tells you a product is made of modern, dependable Steel.

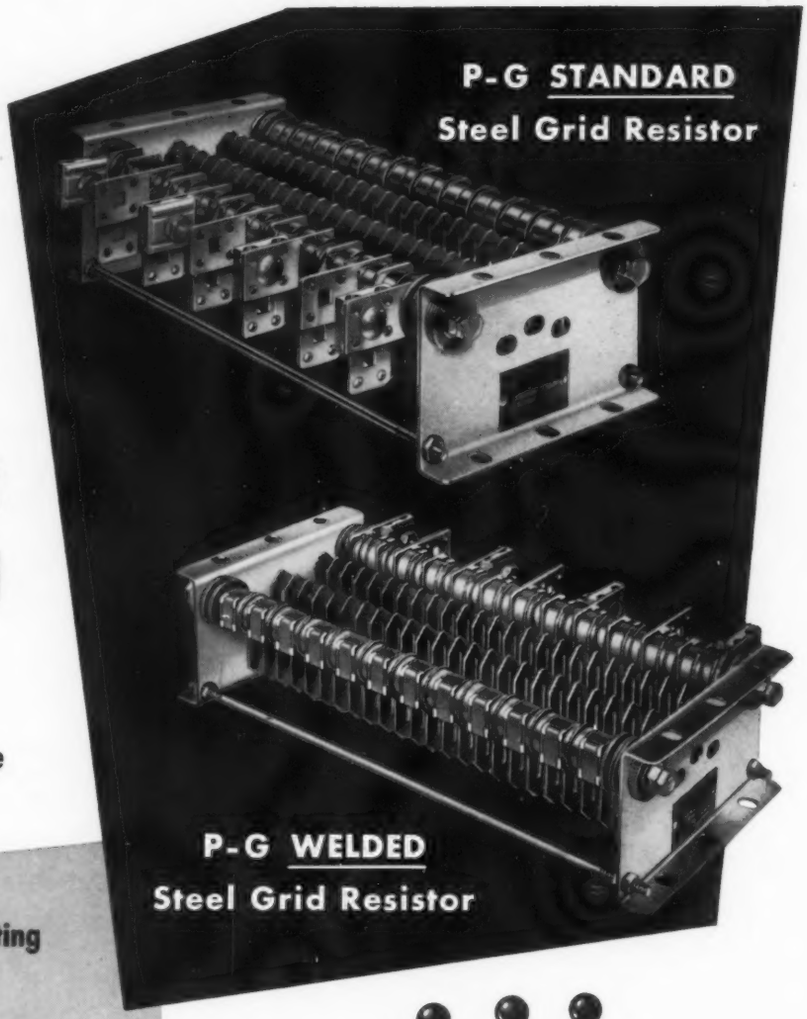
Steel

P-G the ORIGINAL

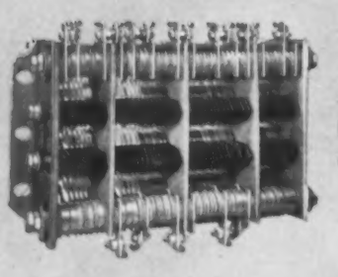
Steel Grid Resistor

plays an essential part in the production of steel

Built for severe service conditions
Protects vital electrical equipment
Constant "trouble free" performance
Quick adjustments easily made

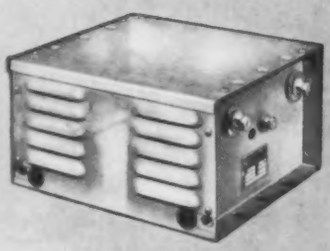


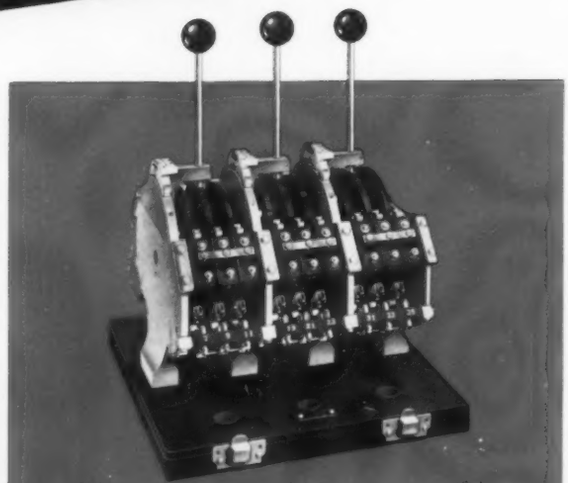
P-G Resistors for Internal Mounting in Face Plate Controllers



Standard Units for 2 to 25 H. P. Motors. Also supplied for external mounting.

P-G Resistors for
SAFETY LIMIT STOPS
Available in standard units for any size motor.





P-G Type MD **Master Switch**
for general application in Mill Service

Save valuable mounting space . . . One to four switches in a single enclosure . . . Overall length less than 22" on four-unit Switch.

Send for Bulletins

P-G
ESTABLISHED 1892

THE **POST-GLOVER** ELECTRIC COMPANY
OFFICE and FACTORY—Kenton Lands Road, Erlanger, Kentucky
MAILING ADDRESS—Box 709, Covington, Kentucky

Equipment News...

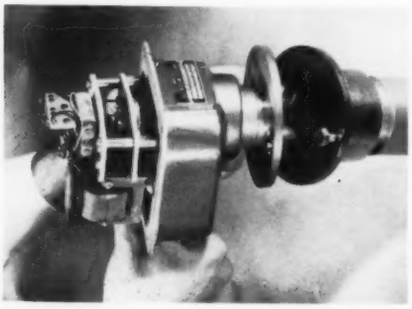
FLAME DETECTOR

△ A new solid-state flame detector which senses the presence of a flame and operates a relay to provide an alarm signal or indication in the event of flame failure contains only eight components, all of high temperature design.

Designated Type UF1100B, the new compact unit which is responsive to radiation in the spectrum from 2000 to 2800 angstrom units and operates effectively at ambient temperatures from minus 20 F to plus 300 F is available from Bailey Meter Co. A flame detector (Type UF1000B) which transmits a signal to a static switch is also available.

The flame detector is designed to monitor individual burners in gas, oil, coal or combination fuel-fired furnaces. It responds only to the flame under surveillance and not to adjacent flames or infrared radiation from glowing refractories. The flame detector sensing element which easily withstands temperatures up to 600 F may be mounted remotely from the detector case.

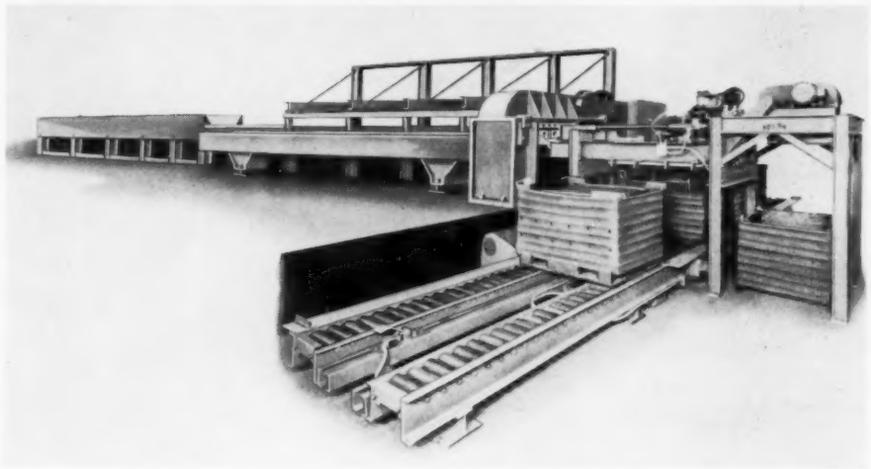
The flame detector relay for alarm actuation has a SPDT contact arrangement and a one or two-second time delay. No external amplifier or relay is required for operation of the detector or for alarm



actuation. This assures reliable operation and minimum maintenance. Relay contact rating is two amperes at 125 volts a-c or two amperes at 25 volts d-c.

Rugged quick-disconnect and keyhole mounting features provide accessibility for ease of maintenance. A two-inch female pipe coupling adapter is also provided with the new unit. The flame detector is enclosed in a light-weight aluminum case with weatherproof fittings to provide protection against weather in outdoor applications.

BAR SHEAR AUTOMATIC CONVEYOR SYSTEM



An automatic system has been developed for feeding, taking away, and loading and handling of containers of a bar shear by the Spurgeon Co. The feeding system uses a hopper type live roll conveyor; the takeaway system uses a conveyor which takes the cut bars away from the shear and loads them into a container which is mounted on a shuttling conveyor. The shuttling conveyor influences the bars to form level rows in the container. The full container is automatically pushed onto a floor type storage conveyor and as this is done an empty conveyor is automatically pushed off the empty container storage conveyor. The entire operation is interlocked both mechanically and electrically to synchronize all components. This system is adapted primarily to the handling of relatively short bars and if the conveyor system is to handle long bars a variation of the design includes automatic runout tables and length gages with automatic unloaders, stackers and bundle strapping units.

SILICONE MOLD WASHES

△ Two new silicone materials for use as washes for ingot molds in the steel industry have been developed by General Electric Co.'s Silicone Products Department.

One, a silicone emulsion for application to hot molds, is designated G-E XM-2020. The other, XS-4017, is a solution of silicone in a fire-resistant, volatile carrier and may be used on both hot and cold molds. Designed specifically for application on ingot molds used for pouring steels, these silicone coatings may also find other uses in the metal-working industries, ferrous and non-ferrous.

These silicone coatings impart nonsticking properties to mold surfaces toward splashes of molten metal. Instead of sticking to mold walls and acquiring oxide coatings, splashes of molten metal drop back into the melt. By elimination of oxided splashes on mold walls, the use of XM-2020 emulsion or XS-4017 solution mold washes yields great improvement in ingot surface quality.

The new products reduce inclusions, pits, folds, scale and other ingot surface defects. In some grades, clear silvery-bright ingot surfaces have been observed. Even when some scale does form, it is less adherent and more easily removed. The resulting ingot surface quality improvement can reduce metal loss —an important factor in high cost alloys; it can shorten ingot preparation time, resulting in reduced labor costs.

In some grades, the improved

HOW TO BEAT THE HEAT

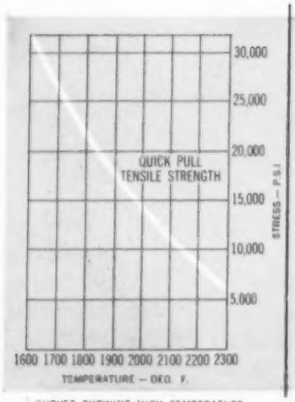
for strong high alloy requirements in the 1,800° to 2,300° F range!

DURALOY HOM*

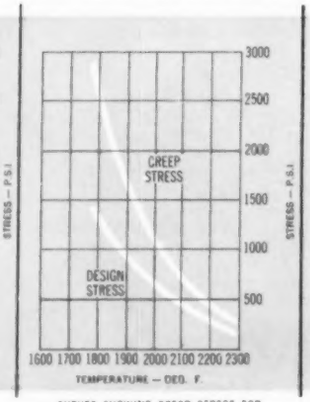
*Covered by U.S. Patents

casting alloy

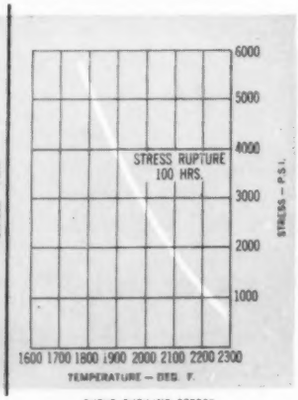
Duraloy "HOM" is a special high nickel alloy developed to produce castings that meet high temperature requirements, especially when castings are subject to oxidizing atmospheres.



CURVES SHOWING HIGH TEMPERATURE SHORT-TIME TENSILE STRENGTH OF DURALOY-HOM



CURVES SHOWING CREEP STRESS FOR CREEP RATE OF 1% IN 10,000 HOURS AND RECOMMENDED DESIGN STRESS FOR DURALOY-HOM



CURVE SHOWING STRESS TO RUPTURE AT 100 HOURS FOR DURALOY-HOM

Castings of DURALOY "HOM" are now being produced by our three methods: static, centrifugal and shell molded. Write today for additional information on this versatile new alloy.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

ingot surface quality imparted by XM-2020 or XS-4017 mold washes speeds up rolling mill operations. Such improved ingots can be fully reduced to size from the initial soaking heat without the need to interrupt rolling to cool, scarf or grind out scale, and reheat the billet. In some carbon steel grades used for forging bars, the use of these silicone mold washes enabled sound forgings to be made without extensive preparation of the ingots prior to rolling. A significant improvement in quality of brite wire drawn from rimmed steel billets was obtained when XS-4017 mold wash was used.

The XM-2020 is a whitish, milky emulsion containing 30 per cent silicone base. It may be used as received, or reduced somewhat with water to suit application needs. The XS-4017 is an aluminum-colored solvent dispersion containing 10 per cent silicone base. Both materials are very fluid and are best applied by air-atomized spray equipment.

MONOLITHIC LININGS

△ Monolithic materials for gunning blast furnace linings have been developed by Harbison-Walker Refractories Co. Some of these gunned furnace linings have been in service for more than three years.

One producer of merchant iron, for example, decided to patch badly worn areas in the inwall in order to get at least two more months of service before a completely new relining was undertaken. But, instead of two months, the furnace ran for 22 months.

A major installation in 1954 involved the repair of a worn brick lining from mantle up. By the time this furnace was blown out, nearly three years later, due to business conditions, a total of 696,800 tons of iron were produced.

According to company spokesmen, several steel plants pioneered the maintenance of blast furnace linings with monolithics over ten years ago. Harbison-Walker supplied the refractories for each of these installations including one of the earliest successful experiments which took place almost 30 years ago.

By mid-1960, no less than eleven major blast furnace monolithic installations were completed by Harbison-Walker, the largest one in 1958,

ARMCO®

WHEELING STEEL

McLOUTH STEEL CORPORATION

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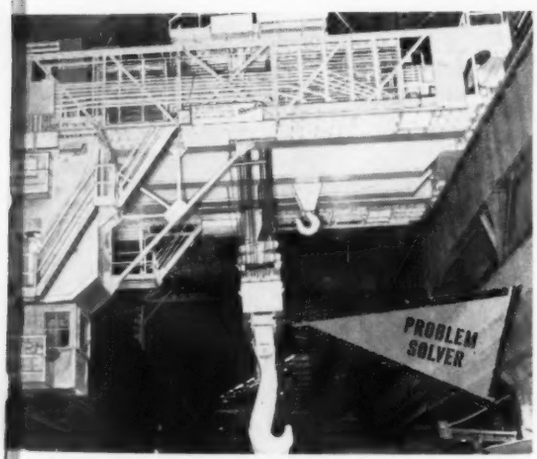

Shaw-Box Ladle Crane. A 4-girder, 9-motor crane with 54 foot span. 90-ton ladle holds 200 tons of molten steel. 75-ton auxiliary trolley handles lighter loads.

Shaw-Box Bucket Magnet Gantry Crane. Our gantries are used to handle plate, slabs, ingots, and scrap. They are built to obtain freedom from whipping and to resist impacts.

These 10 top steel companies solve handling problems with Shaw-Box® Cranes

Standard crane designs of 30 years ago can't solve materials handling problems for today's steel mills. Problems unique to each mill demand cranes especially engineered for the job.

That is why these ten leading steel companies developed their own crane specifications — or chose modern AISE standards. Each awarded the job of constructing the crane to Shaw-Box.

Shaw-Box produces cranes of any type and capacity to AISE standards or your own. Your particular materials handling problems come first. We are not bound by traditional concepts of design. The crane you want is developed for top efficiency, easy maintenance, power economy, and complete safety.

Call in one of our engineers. He will gladly discuss specifications and tell you about our standard AISE designs for 5 to 500-ton cranes. We welcome the opportunity to serve you.

MAXWELL MANNING & MOORE INC. M&M TRADE MARK

60 K-2

SHAW-BOX® CRANES

A product of

MANNING, MAXWELL & MOORE, INC.

ELECTRIC OVERHEAD CRANE INSTITUTE E.O.C.I. MEMBER

Shaw-Box Crane & Hoist Division • Muskegon, Michigan
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HOW WESTERN GEAR SERVES THE STEEL INDUSTRY

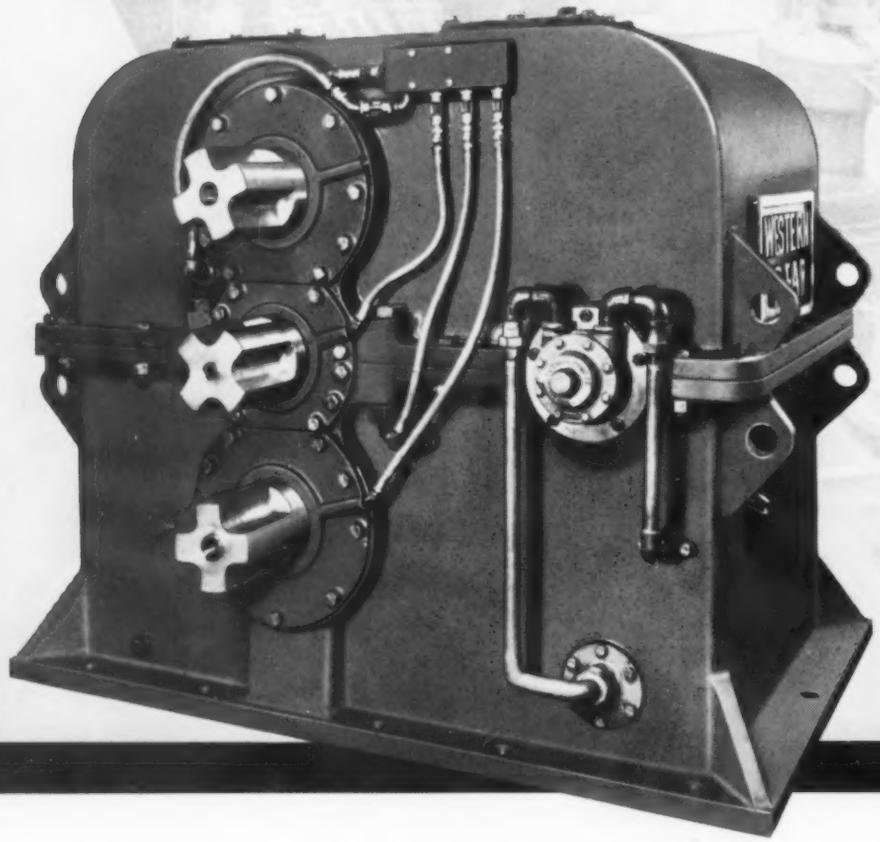
WESTERN GEAR

STEEL MILL EQUIPMENT SAVES YOU MONEY

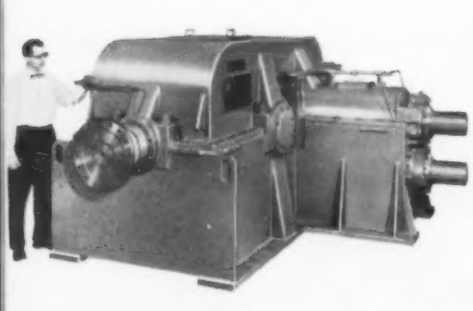
because...on the long run... **QUALITY COSTS YOU LESS!**

From the early days of the steel industry, Western Gear has made continuing studies of the industry's requirements. Today, many major steel mills are equipped with Western Gear speed reducers, pinion stands and combination reducers-pinion stands. ■ Why? Because Western Gear has earned an industry-wide reputation for reliability, and for being able to engineer and deliver the latest in metallurgical developments, tooth design, bearings, and overall rugged construction. ■ Take advantage of this intimate knowledge of America's steel industry. Ask for a Western Gear steel mill application engineer to talk to you about Western Gear's answers to your steel mill needs. For full information ,write, wire or phone collect to: **WESTERN GEAR CORPORATION** Industrial Products Division, P.O. Box 126, Belmont, California • LYtel 3-7611

WG INDUSTRIAL PRODUCTS DIVISION

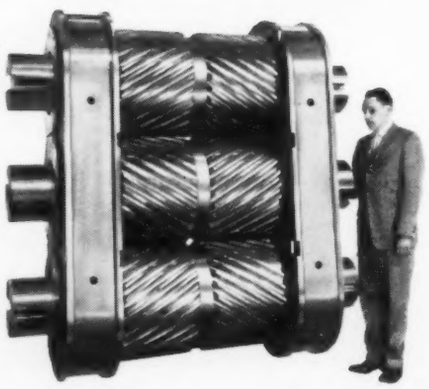


This 3-high pinion stand is combined in one housing with the reduction gears... gives you heavy savings in installation costs and valuable mill floor space. Alloy steel shafts are equipped with anti-friction bearings. Heat treated gears are lubricated by self-contained, circulating oil system. Double helical pinions precision shaved for maximum tooth contact and smoothness of operation. Housing is of heavy, welded, stress-relieved construction.



◀ This 10½ ton integral pinion stand and reducer averages 65% total length as compared to separate units... saves valuable space. First cost lower because fewer parts are involved. Installation costs lower, too, because installation is simpler, faster. Easy to maintain... fewer parts to wear ... large inspection opening simplifies repairs.

Shown here is a 22" center distance 3-high pinion stand ready for placement in the drive housing. Note shaft ends are keyed to allow use of cast wobbler extensions which can easily be replaced when worn out. This is a Western Gear development, designed to meet a specific steel mill customer's requirements. ▶



involved the gunning of 267.5 NT castable from mantle up in the stack including the stock line wear-plate area.

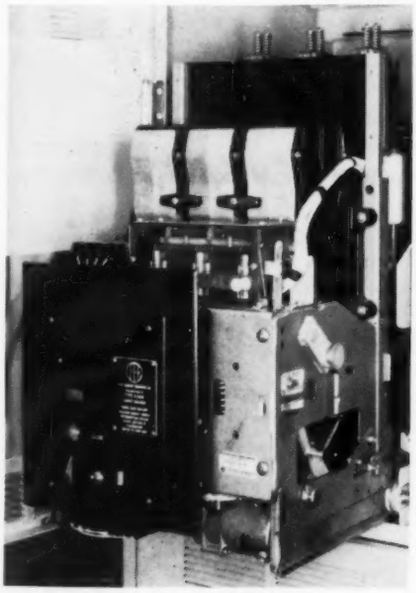
Obvious advantages are saving of good brickwork still in the structure and getting the furnace back on the line as early as possible. Whereas a typical brick relining may take up to 2 months or more, a complete gunned maintenance installation can be accomplished in 10 days or less.

Since this procedure extends the furnace life two or three or even more years, the end results are substantially reduced refractory costs per ton of iron produced.

CIRCUIT BREAKERS

△ I-T-E Circuit Breaker Co. announces the availability of new, low-voltage current-limiting circuit breakers which provide economical high-speed protection against fault currents up to 200,000 amp.

The new, versatile K-Don breakers integrate—in a single switchgear compartment—the fast-acting, high-capacity fault protection of Amp-trap current-limiting fuses with the protective features of its K-Line stored-energy breakers, and a unique device that prevents single phasing.



Trigger-fuse device shown on right, above the escutcheon, prevents single phasing. Part of cylindrically-shaped, current-limiting fuse can be seen above center point in rear.

They provide this additional current-limiting insurance without sacrificing adjusting flexibility of the circuit breaker needed for overcurrent and medium-capacity short-circuit tripping. They provide fault protection for the system, the breaker itself, load-side equipment, and operating personnel. Maintenance is simple.

Application possibilities for the new equipment are numerous, particularly in industrial plants and commercial buildings. K-Don circuit breakers may, for example, be used to:

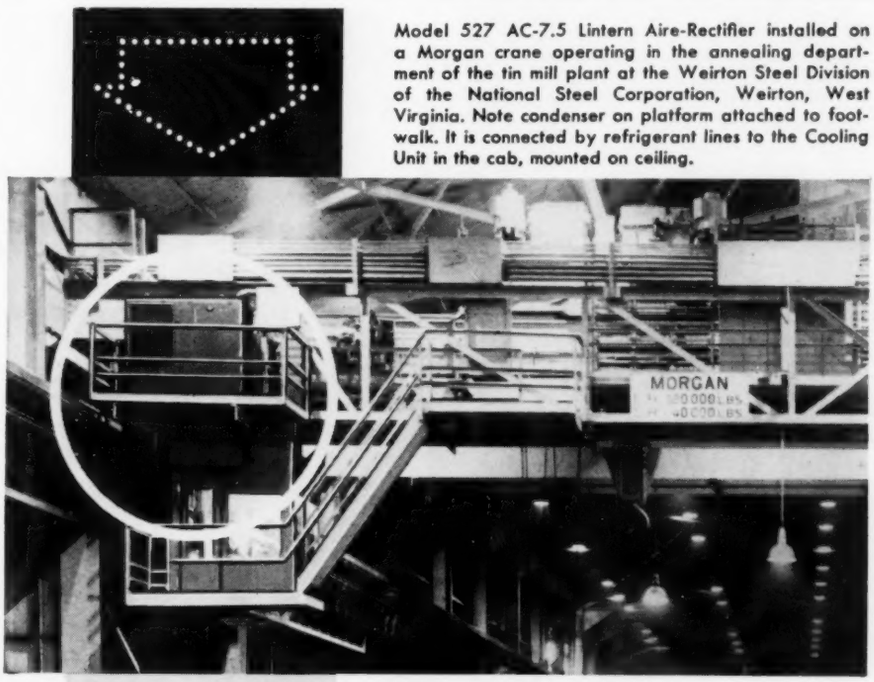
(1) Replace existing breakers where available short circuits, due to system expansion, exceed breaker interrupting capacity;

(2) Protect panelboards with limited interrupting capacity, and

(3) Protect low-voltage bus duct, and other load-side equipment with limited short-circuit withstand capacity.

Current-limiting action—the key to this high-capacity fault protection—is provided by Amp-trap current-limiting fuses which, by interrupting short circuit current in less than a cycle, prevent its reaching a dangerous magnitude.

The Amp-traps take over the protective function at any preselected point either below or at the



Model 527 AC-7.5 Lintern Aire-Rectifier installed on a Morgan crane operating in the annealing department of the tin mill plant at the Weirton Steel Division of the National Steel Corporation, Weirton, West Virginia. Note condenser on platform attached to footwalk. It is connected by refrigerant lines to the Cooling Unit in the cab, mounted on ceiling.

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CAPITAL EQUIPMENT

by **LINTERN** AIR CONDITIONING

By air conditioning crane cabs and pulpits, plants are making the most of profit opportunities — achieving full use of costly equipment and getting the most return on capital investment.

Lintern Aire-Rectifiers are made in a range to meet all conditions — from 90°-230° F. More than two thousand are in daily service on practically every type of crane and pulpit operation in steel, aluminum, copper, and other industrial plants, wherever excessive heat, dust, gas and fume conditions are prevalent.

ASK FOR BULLETIN AC-573.

Larco, inc.
DISTRIBUTOR OF LINTERN CORPORATION PRODUCTS
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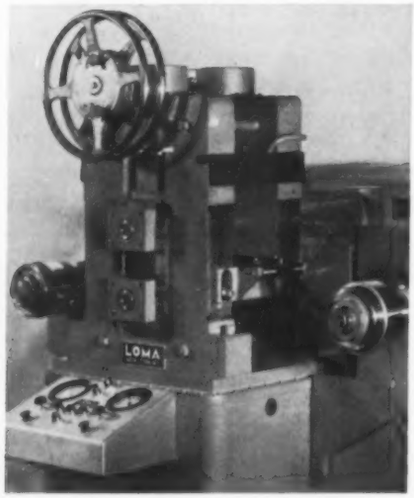
NEWS FROM

LOMA



This rugged and versatile reversing 2-high / 4-high combination mill brings high-precision rolling of thin-gauge ferrous and non-ferrous strip within reach of the smaller re-rolling mill, metals pilot plant and research laboratory. Occupying only 35 sq. ft. of floor space and involving a cost of less than $20,000, the machine handles up to 6 in. wide strip at rolling speeds up to 250 ft. per min. with accurate front and back tension control.

The new 8 in. mill is furnished with two sizes of 4-high work rolls, made of either alloy tool steel or solid tungsten carbide: the 1½ in. size is used for normal cold reduction down to 0.002 in. thickness, and the ¾ in. size allows special ultra-thin finishing to gauges of less than 0.001 in. In the 4-high setup, the machine handles up to ⅛ in. gauge; the 2-high arrangement is used for the hot or cold breakdown of heavier materials up to 1 in. thick, but is also available for skin pass rolling of thin strip.

The production of close-tolerance stock is assured by an exceptionally rugged mill design, employing steel housings of 160 sq. in. post area, super-precision needle roller journal bearings of 175,000 lb. separating force capacity, a heavy-duty mill drive with herringbone gearing and universal joint spindles, and twin-handwheel worm drive screwdowns. The machine is powered by a four-speed reversing drive offering constant horsepower from 40 to 250 ft. per min. rolling speed.

The outstanding feature of the new machine is its reversing strip coiling attachment allowing the two-way rolling of strip under tension control with no more effort than a mere flick of a selector switch. Mounted on brackets at either side of the mill, the two coiling shafts carry 8 in. diameter reels designed for a coil buildup of 6 in. Both shafts are driven from the pinion stand and are provided with dual air-operated slip clutches and brakes of ultra-sensitive, low-inertia design. Selective operation through solenoid valves and pressure regulators precisely controls the front and back tensions desired for any given mill pass.

LOMA

MACHINE MFG. CO., INC.

114 East 32nd Street

New York 16, N. Y.

breaker's interrupting-capacity rating. They will not blow below the preselected point; hence, nuisance replacements are avoided.

The current-limiting fuses are easily bolted in place when replacements are required. Located in the rear of the unit, they are inaccessible until the breaker is tripped open and withdrawn from the compartment. Closed-circuit contact with fuses is, therefore, impossible.

The breaker may, in addition, be tilted forward when withdrawn and locked in this position for added elbow room.

The current-limiting fuses are connected in series to the line side and in parallel with a device which provides protection against single phasing.

This device consists of three small Trigger fuses—each containing a spring-loaded link—connected to a common tripper bar. If any one of the Trigger fuses blows, it activates the tripper bar which opens all three poles simultaneously.

An interlocking arrangement prevents closing the breaker until blown fuses have been replaced.

In addition, the Trigger fuses are accessible from the front of the breaker for easy replacement. And, because the Trigger-fuse housing is transparent, the operator can readily see whether a fuse has blown or the breaker has been tripped by the overcurrent device.

The circuit breakers are available for electrical or manual stored-energy operation in two frame sizes: K-Don 600, continuous current rating 30 to 600 amps, and K-Don 1600, continuous current rating from 150 to 1600 amps, for applications up to 600 volts a-c or 250 volts d-c. Both provide fault-current interruption up to 200,000 rms amps.

Ratings of Amp-trap current-limiting fuses for the K-Don 600 range from 400 to 2000 amps; and for the K-Don 1600 from 400 to 3000 amps.

CLOTH DUST COLLECTOR

△ An order for the first full-scale application of cloth bag filtration to open hearth steel furnace gas cleaning has been received by Dracco Division of Fuller Co. A ten-compartment glass-bag filter will be

We bet millions on our couplings

When you buy a Fast's coupling, you can bet your bottom dollar everything was built on the spot, not assembled piece by piece from other suppliers. Koppers multi-million dollar manufacturing facilities are the most modern in the industry . . . with advanced program machines, highly accurate gear shapers, a complete forge shop.

For example, all Fast's Couplings are jig-drilled and jig-reamed for greater interchangeability of parts. Result: you get high-quality, smooth-running, long-lived units that are the choice of more equipment manufacturers than any other gear-type coupling.
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KOPPERS

FAST'S COUPLINGS

Engineered Products Sold with Service

used to clean combustion gases from a large oxygen-lanced open hearth furnace and prevent air pollution at a major steel plant.

The glass cloth baghouse will be equipped with sonic generators which will periodically dislodge accumulated dust and fume from filter bag surfaces. The patented apparatus removes dust deposits more effectively than methods previously employed and prolongs service life of the relatively fragile glass fabric. Sonic cleaning does not produce the damaging stresses in the cloth which occur when it is flexed or shaken.

The glass cloth collector will provide greater collection efficiency and is believed to cost substantially less than electrostatic precipitators which have been previously used for open hearth gas cleaning. The Dracco unit will clean furnace gases at a maximum rate of 125,000 cfm at 525 F.

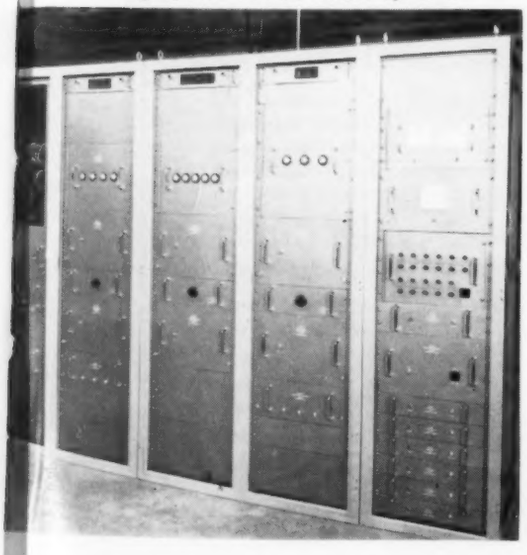
AUTOMATED CONTROL

△ One of the most complete control systems yet designed for steel rolling mill operation is now nearing completion by Datex Corp. The automatic, card-programmed system will control a 56-in. reversing rougher of a semi-continuous hot strip mill at Republic Steel Corp.

Datex equipment will automatically program all numerical positioning of the complete rolling operation, from entry tables to delivery tables, as well as provide start, stop, slowdown and reversing signals to the mill. No manual intervention will be required during normal mill operation.

Datex digital data systems permit control of quality and quantity through measurement of extremely small changes in the physical characteristics of steel during its production.

Shown are five of eight cabinets of instrumentation. The system will automatically start, stop, reverse and position slabs. It will set roll openings of reversing mill (roll positioning to ±0.001 in.), roughing scalebreakers and vertical edgers. The system will operate sideguards, provide digital information to data processor for production monitoring, automatically provide draft compensation of vertical edger, and control table speeds.



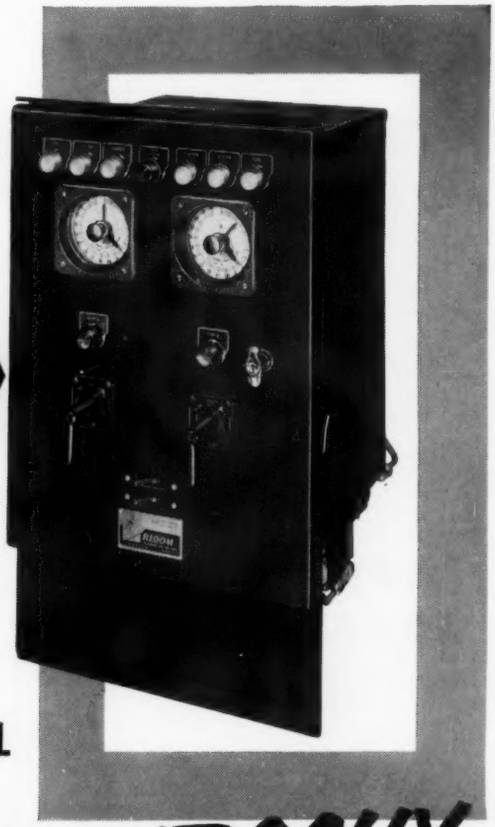
ROD STRAIGHTENER

△ The Lewis Machine Co. has completed and delivered to a leading steelmaker, a new high speed straightening and cutting machine to handle up to 1 in. rod from the coils.

This machine is powered by a hp wound-rotor motor and a 15 hp variable speed motor. The machine, which is 85 ft long has a 60 ft cutoff and weighs over 46,000 lb.

Features of advanced machine design have been incorporated, such as crank action, high-speed flying shear type cutoff—two-speed rotary

The BLOOM Time-Cycle Reversal Unit



assures FULL, FAST AND EFFICIENT REVERSAL OF REGENERATIVE FURNACES AUTOMATICALLY

This complete, compact, factory-tested unit provides a combination electric-pneumatic system for Open Hearth Furnace and Soaking Pit reversal. It eliminates reversal puffing and shortens reversal period. (10 to 15 seconds easily accomplished).

Shorter reversal cycle improves furnace life.

These units have been in continuous service for nine years. Trouble-free maintenance.

BLOOM ENGINEERING CO., INC.
857 W. North Avenue · Pittsburgh 33, Pa.

WRITE or phone for complete information on the Bloom Time-Cycle Reversal Unit.

straightener arbor with dual-center straightening dies for faster, more accurate straightening over a wide range—dual-range pushbutton operated pneumatic feed pressure for exact feed control and coil end pull-through, without twisting (air clutch and air brake actuated by extremely sensitive electric trip with accurate and positive length gaging mechanism) a positive sliding gear type transmission with eight feed speeds of 115 to 350 fpm in any rod diameter from ½ in. to 1 in.

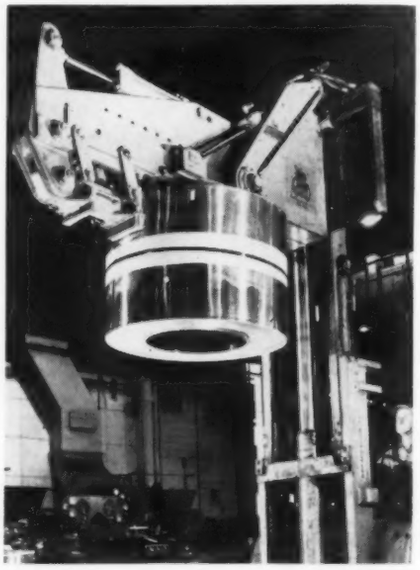
The unit is designed to handle either cold drawn or hot rolled rod. For hot rolled rod an exhaust hood and blower is available to draw off the loose scale.

In the past, large diameter rods have been produced by the drawbench method at a low production rate and with considerable scrap loss. Now, rods up to 1 in. diam can be produced on a rod mill at high speed, in coils, then straightened and cut at high speed, with more accurate straightness, positive length control and scrap saving.

Two-plane roll type straighteners are available to handle flat, square, hex and shapes.

FORK TRUCK ATTACHMENT

△ Many of the old problems of coil handling were solved by the Bridgeport Brass Co. and the Grand Specialties Co. when they jointly developed a new piece of equipment called the Coil Manipulator J-2611.

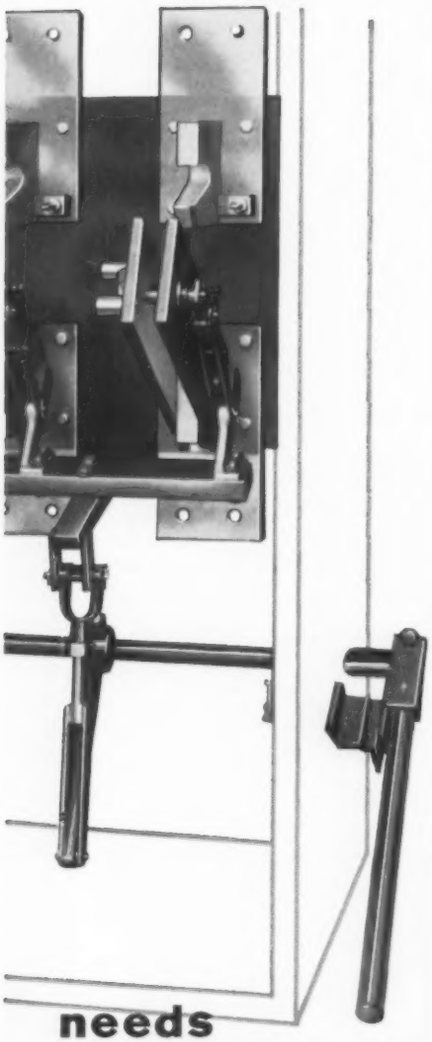


Grand built this device, which is adaptable to any standard fork truck, and with it one operator can

(*Please turn to page 232*)

RARELY

(IF EVER)



needs

MAINTENANCE

Pringle disconnect switches for high-current equipment carry as much as 50,000 amperes, continuously, with no more of a heat rise than you would get from copper bus bars bolted together. These switch blades actually are bolted together. Under a constant pressure of 600 lbs./sq. inch. Without springs. Yet, they open easily after months (or years) of closed operation. Heat, fatigue, lack of movement won't affect the operating mechanism. Constant, periodic maintenance is unnecessary.

Less complex than most high-capacity disconnect devices. Less expensive too. Available in single- or multi-pole models, front or rear connected, live front or steel enclosed. With or without high-capacity fuses. For use on crane conductor rails, transformer secondaries, or AC and DC switchboards. Wherever high-current equipment must be isolated for periodic servicing.

Write for Industrial Switch Catalog

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ELECTRICAL MANUFACTURING CO.

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What makes the first gear-type coupling still first choice?

Check design . . . and you'll find Fast's Couplings (the original gear-type couplings) are superbly engineered, ruggedly built, smoothly running units designed to outlast the machines they connect.

Check completeness of line . . . and you'll find Fast's Couplings come in a complete range of sizes and types for shafts from ½" to 32" and larger.

Check service . . . and you'll find Fast's Couplings are backed by expert help from experienced field engineers . . . while outstanding stock facilities throughout the country insure speedy delivery of your coupling orders.

Check popularity . . . and you'll find Fast's Couplings are the choice of more industrial equipment manufacturers than any other shaft coupling.

Check Fast's for your coupling needs today.

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Equipment News

(*Continued from page 230*)

grab coiled metal stock weighing up to 6000 lb., lift it and invert it from a horizontal to a vertical position in one operation. High pressure clamps adjust to any coil size and curvature while holding the coil securely.

The Bridgeport Brass Indianapolis, Ind., plant uses the coil manipulator to invert large coils of brass stock for flat stacking or further processing, which eliminated the need for the extra operation of a converter table. By flat stacking, the problem of coil telescoping and dented edges was practically eliminated, thus cutting coil rejections down to a minimum. It also permits more efficient use of floor space, as the coils may be stacked to the height of the fork truck lift.

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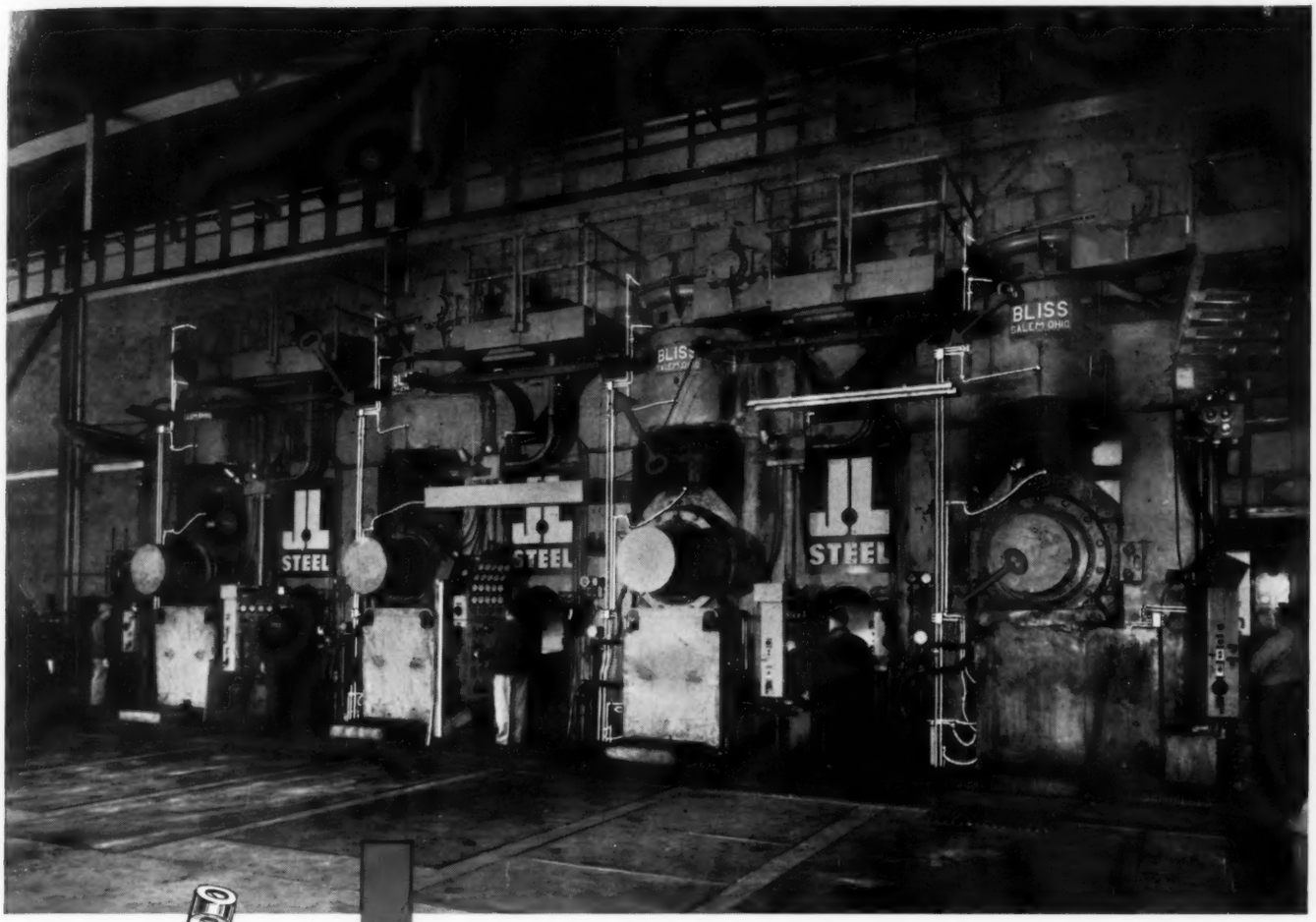

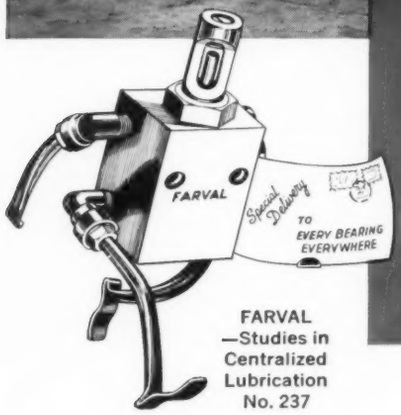

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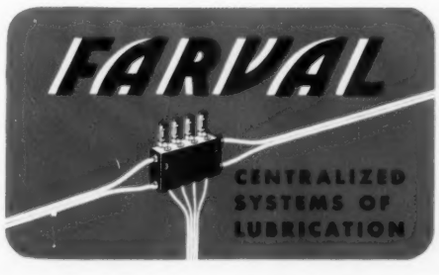

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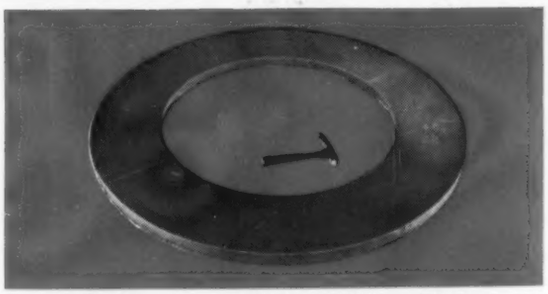

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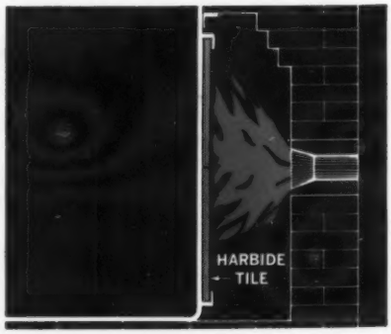

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